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DESTRUCTION OF UNDERSIZED HADDOCK ON GEORGES BANK, 1947-51

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Explanatory Note

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Washington, D. C.
May, 1953

United States Department of the Interior, Douglas McKay, Secretary
Fish and Wildlife Service, Albert M. Day, Director

DESTRUCTION OF UNDERSIZED HADDOCK ON GEORGES BANK, 1947-51

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THE DESTRUCTION OF UNDERSIZED HADDOCK ON GEORGES BANK, 1947-1951.

The destruction of undersized haddock on Georges Bank has been going on since the introduction of the otter trawl in 1905. This waste of small fish has been of great concern to the industry and to conservationists for many years. The Fish and Wildlife Service has been studying this fishery intensively since 1931, and has at various times urged the use of a larger-meshed net in order to curb the destruction of haddock too small to market (Herrington, 1932, 1935, 1936; Schuck, 1947, 1948; Royce and Schuck, 1950) but, since the banks lie in international waters, no legislation was ever enacted.

With the organization in 1951 of the International Commission for the Northwest Atlantic Fisheries, it became possible to control the fisheries of these banks, and appropriate regulations are now being promulgated by Canada and the United States to set the minimum size of mesh allowable for haddock fishing on Georges Bank and in the Gulf of Maine (subarea 5 of the Commission).

In connection with these regulations, it is necessary to have accurate information on the numbers and sizes of fish discarded at sea before and after the regulations are applied, in order to assess the effectiveness of the larger mesh in actual practice.

Extensive observations (61 sea trips) were made by Bureau of Fisheries observers (Alexander, Moore, and Kendall, 1915) in 1913-14, and from data collected it was possible to estimate the quantities of haddock discarded in these years. Herrington (1932, 1935, 1936) estimated the quantities of haddock discarded for the years 1930-32 by sampling at sea (20 trips) and by port interviews of vessels. The present report extends these data to include the results of port interviews for the years 1947 to 1951 and the samplings at sea for the year 1951.

The success of this study has been made possible by the wholehearted cooperation of the fishing industry. We wish to express our appreciation to all the fishermen interviewed and especially to the crews of the trawlers on which the observers shipped. An extra man on board may interfere with normal operations, but the observers have found the fishermen most willing to afford them an opportunity to collect the necessary data. The boat owners have been very cooperative in permitting the observers to sail on these trips.

Howard A. Schuck was in charge of haddock research when these studies were conducted. Credit is due him for supervising the sampling-at-sea program during its initial stages. The following persons collected data at sea: John R. Clark, Sterling L. Cogswell, David F. Hammack, George F. Kelly, John F. Shea, and the author. Port Interviews were conducted by James J. Miggins and David F. Hammack. Betty B. Murray and Sterling L. Cogswell assisted in the tabulation of the data.

METHODS

For many years, the Service has stationed a man at the Boston Fish Pier to collect biological information on the haddock landed there. This agent measures the lengths of a sample of each catch, collects scales for age determination, and interviews the captains of the vessels to obtain information on the area of capture. Since 1947 the interviewer has also obtained from the captains their estimates of the pounds of haddock discarded on each trip and the area in which the destruction occurred.

In 1951, a system was inaugurated for obtaining more detailed information on the fish discarded. In this program trained observers are sent to sea on commercial trawlers to count and measure the fish discarded and to collect scale samples for age determination. Similar data are collected from the retained portion of the catch. A trawler, typical of those on which observations were made, is shown in figure 1.

In normal fishing operations, the entire catch from a haul is dumped into one or more checkers (fig. 2). From these checkers the marketable fish are selected and separated according to species. The haddock are graded for size, then gutted and tossed into a wash box from which they are pitched below decks for icing. The biologist usually obtains his measurements and scale samples of the marketable fish before the fish are gutted.

The unmarketable fish remaining in the checkers are washed overboard through the scuppers. The biologist takes a sample of these just before they are discarded (see fig. 3). Lengths of fish are measured by the punch-strip method (see fig. 4). In this method, each fish is laid on an alumium strip and its length recorded by punching the strip with an ice pick. The actual lengths are measured after return to the laboratory. The lengths of several hundred fish can be rapidly recorded in this way on a single strip by a single observer without use of notebook.

During 1951, seven trips were made by the sea sampling observers. The trips were made on the following trawlers: Barbara C. Angell, Crest, Drift, Michigan, Red Jacket, and Winchester. The dates and areas fished on these trips are listed in table 1. Most of the fishing was conducted on the Northern Edge, where a total of 326 sets were made. One hundred and ten sets were made on the Southeast Part, and 36 sets on the eastern side of South Channel.

ESTIMATED DESTRUCTION, 1947-51

The destruction of haddock on Georges Bank by the Boston fleet[1/] for the years 1947 to 1951 is summarized in table 2.

1/ The estimates for the entire New England fleet are almost 50 percent greater than those reported here.

Figure 1.--A Boston trawler, typical of those on which observations were made at sea.

Figure 2.--Checkers full of haddock, immediately after one set of the net has been emptied on deck

Figure 3.--Undersized haddock. These fish were discarded as soon as the Fish and Wildlife Service observer measured them. Note measuring equipment in foreground.

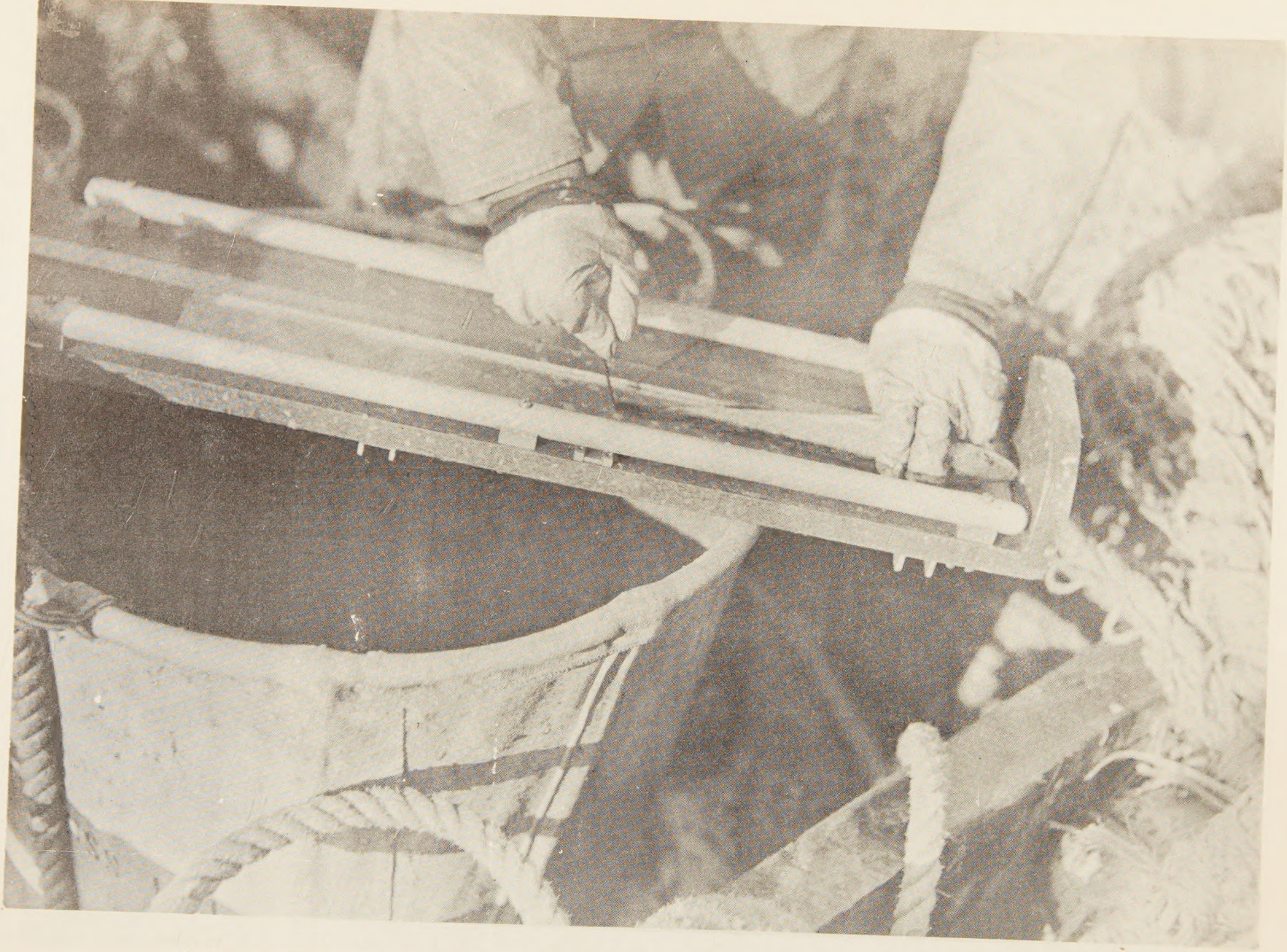


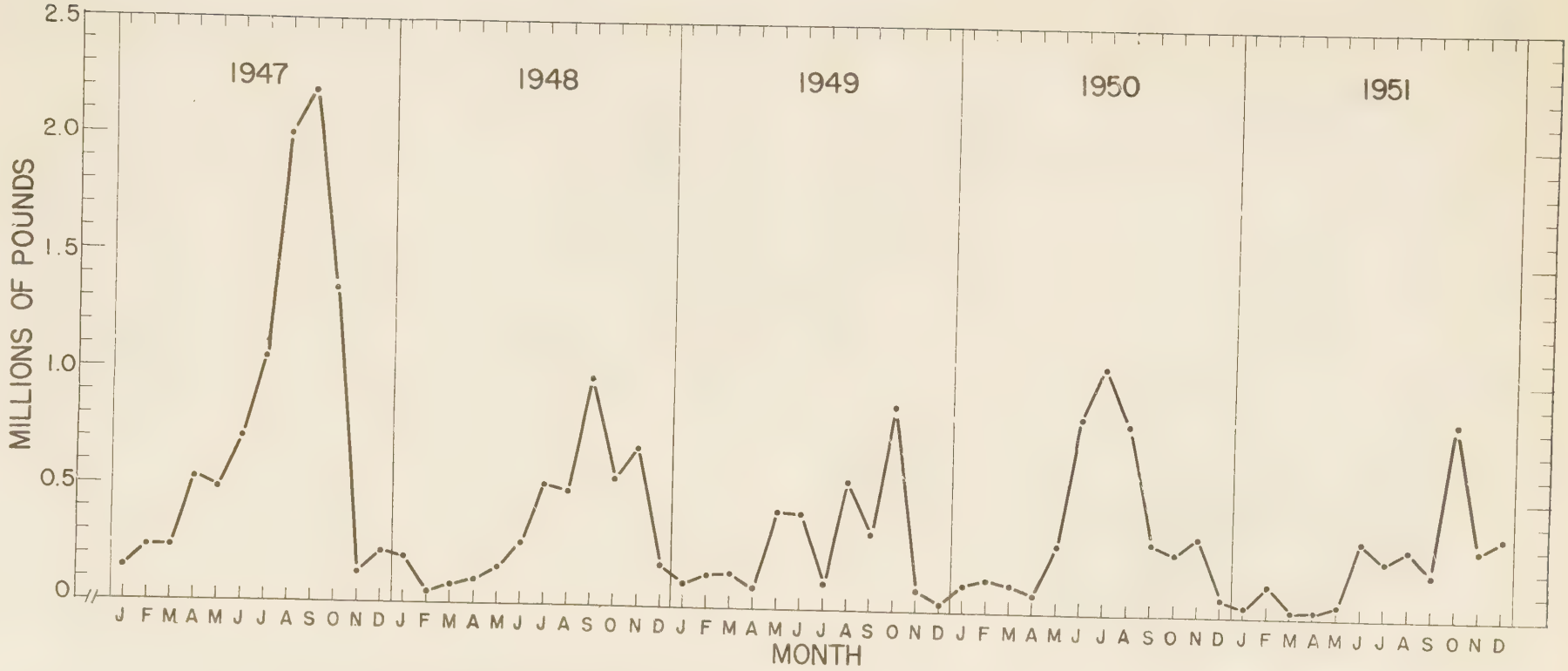
Figure 4.--Observer measuring a sample of discarded baby haddock by the punch strip method.

TABLE 2.--Destruction of haddock on Georges Bank by the Boston fishing fleet, 1947-51 /in thousands/

Year-Month	Pounds			Numbers		
	Total catch	Discards	Percent discarded	Total catch	Discards	Percent discarded
1947-January	5,658	146	2.6	1,880	182	9.7
February	5,744	232	4.0	2,094	290	13.8
March	5,598	234	4.2	2,048	292	14.2
April	8,489	531	6.2	3,269	664	20.3
May	6,487	489	7.5	2,987	611	20.4
June	6,611	711	10.8	3,226	889	27.6
July	6,315	1,050	16.6	3,398	1,312	38.6
August	11,317	2,074	18.3	6,931	2,592	37.4
September	12,589	2,189	17.4	7,618	2,736	35.9
October	12,443	1,347	10.8	6,893	1,684	24.4
November	3,467	131	3.8	1,248	164	13.1
December	3,563	221	6.2	1,362	276	20.3
All months	88,281	9,355	10.6	42,954	11,692	27.2
1948-January	3,016	200	6.6	1,165	250	21.4
February	2,178	49	2.2	800	61	7.6
March	5,128	81	1.6	1,852	101	5.4
April	7,570	105	1.4	2,721	131	4.8
May	2,741	160	5.8	1,459	200	13.7
June	6,968	265	3.8	3,601	331	9.2
July	7,595	519	6.8	4,101	649	15.8
August	8,998	491	5.4	4,450	614	13.8
September	9,184	977	10.6	4,921	1,221	24.8
October	8,381	548	6.5	4,217	685	16.2
November	5,985	679	11.3	3,251	849	26.1
December	3,414	180	5.3	1,689	225	13.3
All months	71,158	4,254	6.0	34,227	5,317	15.5
1949-January	4,442	104	2.3	2,094	130	6.2
February	6,975	142	2.0	2,886	178	6.2
March	6,920	149	2.2	2,526	186	7.4
April	3,906	90	2.3	1,431	112	7.8
May	5,785	419	7.2	3,066	524	17.1
June	7,723	412	5.3	3,978	515	12.9
July	5,841	113	1.9	2,854	141	4.9
August	9,671	553	5.7	4,584	691	15.1
September	9,101	329	3.6	4,157	411	9.9
October	5,791	876	15.1	3,194	1,095	34.3
November	1,802	90	5.0	638	112	17.6
December	1,757	33	1.9	570	41	7.2
All months	69,714	3,310	4.7	31,978	4,136	12.9

TABLE 2.--Destruction of haddock on Georges Bank by the Boston fishing fleet, 1947-51 continued
/in thousands/

Year-Month	Pounds			Numbers		
	Total catch	Discards	Percent discarded	Total catch	Discards	Percent discarded
1950-January	2,652	114	4.3	921	142	15.4
February	3,978	140	3.5	1,337	175	13.1
March	3,025	120	4.0	1,029	150	14.6
April	1,744	77	4.4	600	96	16.0
May	5,288	290	5.5	3,061	362	11.8
June	5,745	836	14.6	3,695	1,045	28.3
July	7,683	1,053	13.7	4,896	1,316	26.9
August	10,299	810	7.9	6,837	1,012	14.8
September	8,608	307	3.6	5,480	384	7.0
October	7,568	268	3.5	4,816	335	7.0
November	5,728	332	5.8	3,441	415	12.1
December	4,500	74	1.6	2,574	92	3.6
All months	66,818	4,421	6.6	38,687	5,523	14.3
1951-January	4,103	44	1.1	2,332	55	2.4
February	8,263	139	1.7	3,065	174	5.7
March	4,218	26	0.6	1,524	32	2.1
April	2,239	27	1.2	821	34	4.1
May	6,397	53	0.8	3,548	66	1.9
June	6,216	327	5.3	3,641	409	11.2
July	7,217	241	3.3	4,129	301	7.3
August	12,189	292	2.4	6,252	365	5.8
September	11,056	188	1.7	5,612	235	4.2
October	7,732	834	10.8	4,455	1,042	23.4
November	4,359	293	6.7	2,048	366	17.9
December	3,190	324	10.2	1,591	405	25.4
All months	77,179	2,788	3.6	39,018	3,484	8.9


2.5
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MILLIONS OF POUNDS
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MONTH

Figure 5.--Estimated monthly destruction (in pounds) of baby haddock discarded on Georges Bank by the Boston fishing fleet, 1947-51.

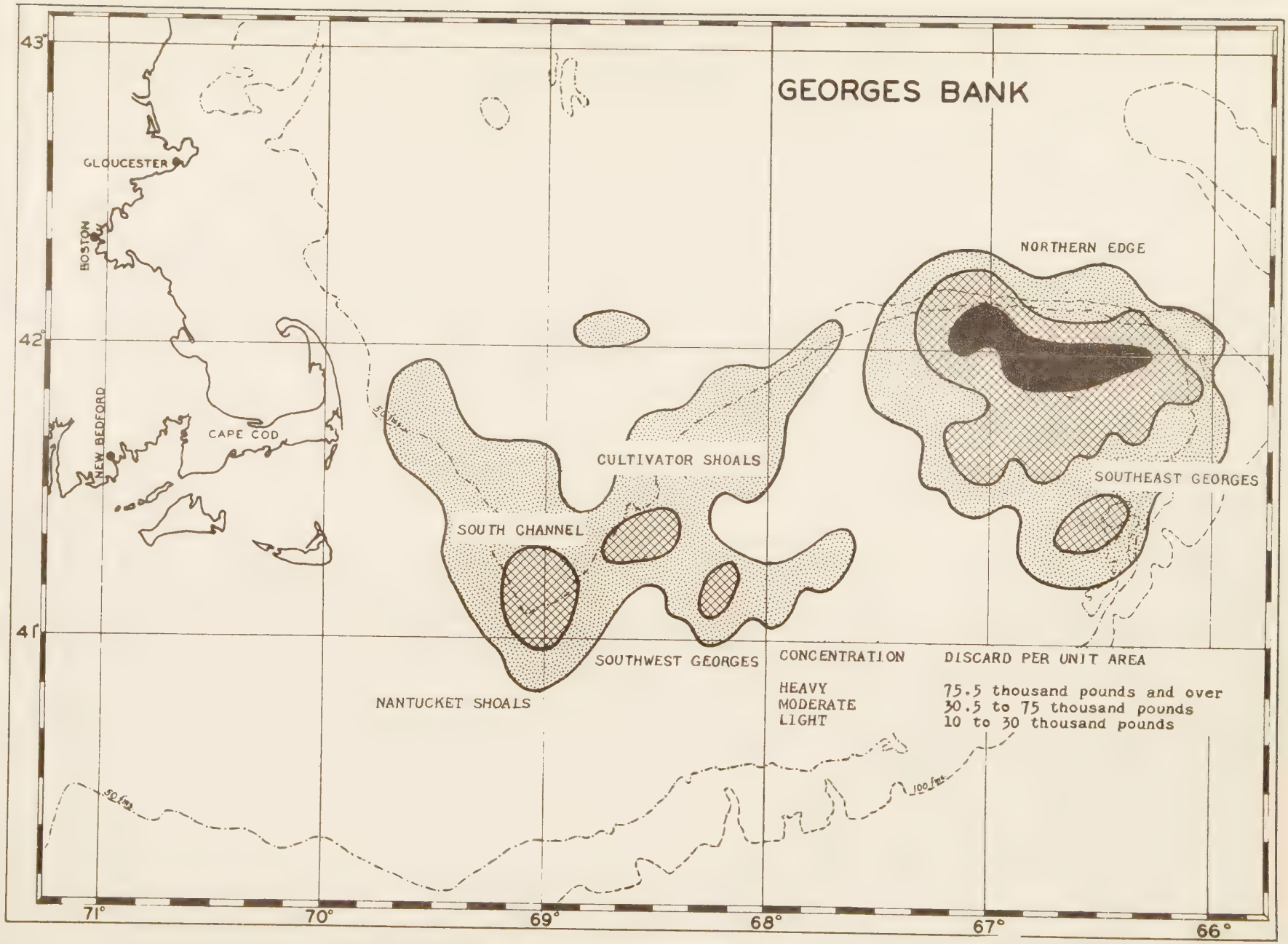

Figure 6.--Localities where haddock were discarded in the average year, 1947-51.

TABLE 1.--Dates and areas fished on the commercial trips observed in 1951

Trip Number	Date	Areas fished on Georges Bank
51-1	June 6-14	Northern Edge Southeast Part East side South Channel
51-2	July 18-25	Northern Edge
51-3	August 3-10	Northern Edge
51-4	August 7-14	Northern Edge Southeast Part
51-5	August 13-21	Southeast Part
51-6	August 29 - September 5	Northern Edge
51-7	September 22 - October 1	Northern Edge East side South Channel

Annual

The average quantity discarded annually during the 5-year period was over 4 1/2 million pounds, representing over 6 percent of the catch. In terms of numbers this quantity represented over 6 million individual fish or over 16 percent of the catch.

The greatest quantity discarded during this period was reported in 1947, when almost 11 percent of the total catch, by weight, was discarded at sea; this was equivalent to discarding 25 percent of the haddock caught. The least discard during this period was in 1951, when about 4 percent of the catch, by weight, was discarded; this amounted to 10 percent of the fish caught. The years 1948-50 were intermediate.

Seasonal

The destruction of baby haddock is definitely seasonal, as can be seen by a comparison of the monthly records (table 2 and fig. 5). Discards usually increased rapidly after June and declined after October. November to May were usually periods of relatively low destruction.

Areas

Discard by area was summarized by plotting the amounts of discard by units of 10' latitude by 10' longitude. The localities where haddock were discarded in the average year for the period 1947 to 1951 are shown in figure 6. The areas of greatest discard were the Northern Edge and

Southeast Part on Georges, with lesser quantities discarded along the 50-fathom contour on the western side and bottom of South Channel, extending northeastward to Cultivator Shoals.

Large discards in certain areas on Georges are not due entirely to the presence of large numbers of small fish, but in great part to the fishing effort expended in the area. The distribution of fishing effort in the average year is shown in figure 7 (Schuck, 1953). The similarity of the discard and effort concentration charts is immediately evident. The areas most heavily fished reflect, in most cases, the greatest discard.

ANALYSIS OF DISCARDS, 1951

Pounds

On the seven trips observed in 1951, a total of 46,608 pounds of baby haddock was discarded. This was an average of 6,658 pounds per trip, with individual trips ranging from 0 to 19,685 pounds (table 3). For all trips, about 7 percent of the total catch by weight was discarded, while on individual trips, percent discarded ranged from 0 to 17.

Numbers

These 46,608 pounds represented 61,802 individual fish, an average of 8,828 per trip. Numbers discarded ranged from 0 to 28,135 on the individual trips (table 4). Of the total numbers caught on these trips, about 17 percent was discarded, while on individual trips, the percentage discarded ranged from 0 to 39.

Estimated total destruction

Using the average discard per trip from the sea sampling data, it was possible to estimate the total destruction by the Boston fishing fleet for the period sampled (June to September). The estimate employing this method was 1,198,000 pounds.

Referring to table 2, we find that the destruction of haddock by the Boston fleet estimated on the basis of skippers' reports, during the 4-month period which parallels the sea sampling trips, was 1,048,000 pounds. The estimate by this method was 12.6 percent under that from sea sampling data.

Average weight

It is recognized that when haddock are scarce, fishermen tend to save fish of smaller sizes, whereas when plentiful, they discard larger fish. This explains the extreme variability in average weights in table 5. To show this more clearly, the average weight of discards was plotted against the total pounds landed for each of the trips on which fish were discarded (fig. 8).

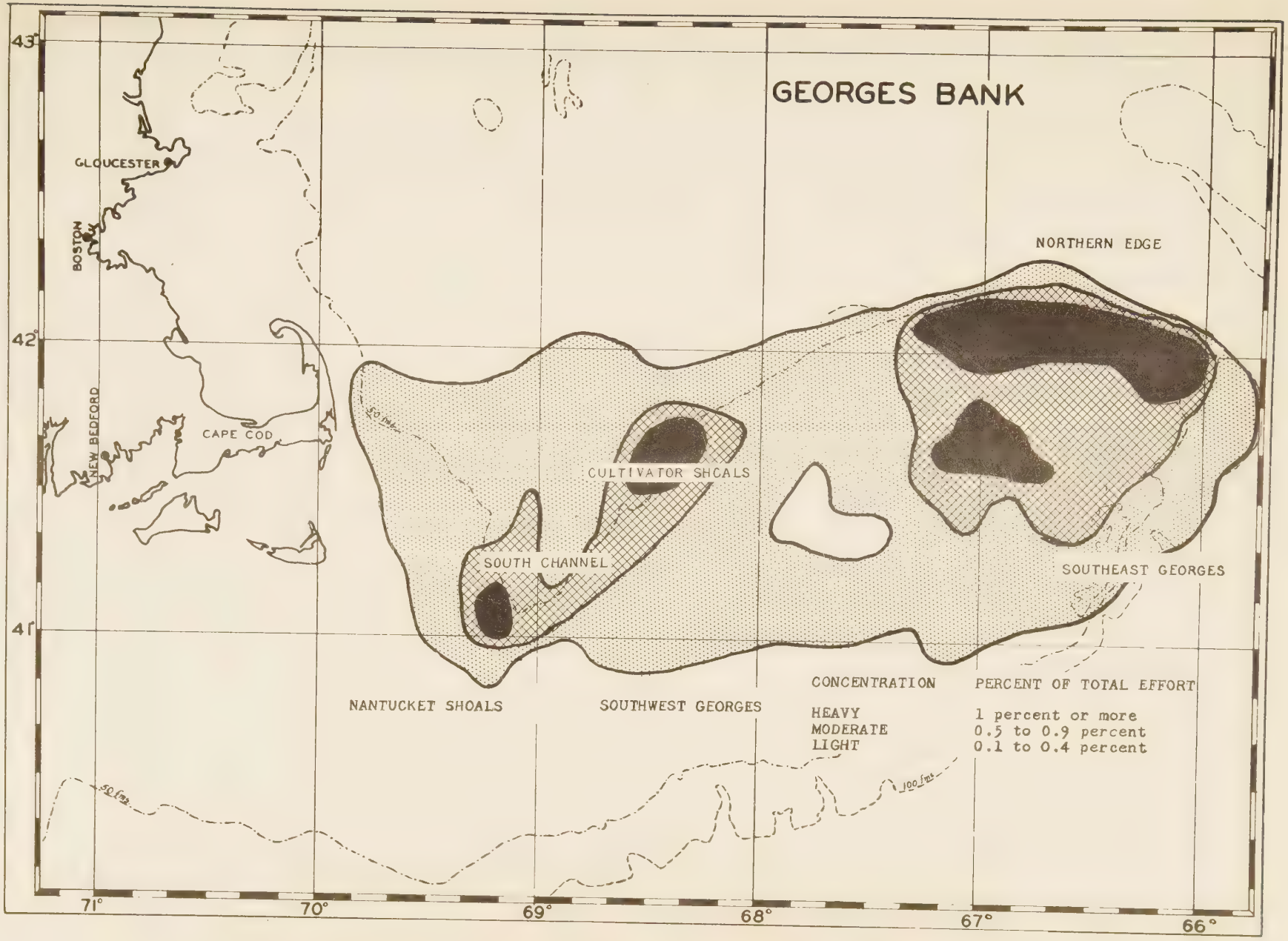

Figure 7.--Distribution of fishing effort of Boston fishing fleet in the average year, 1938-49.

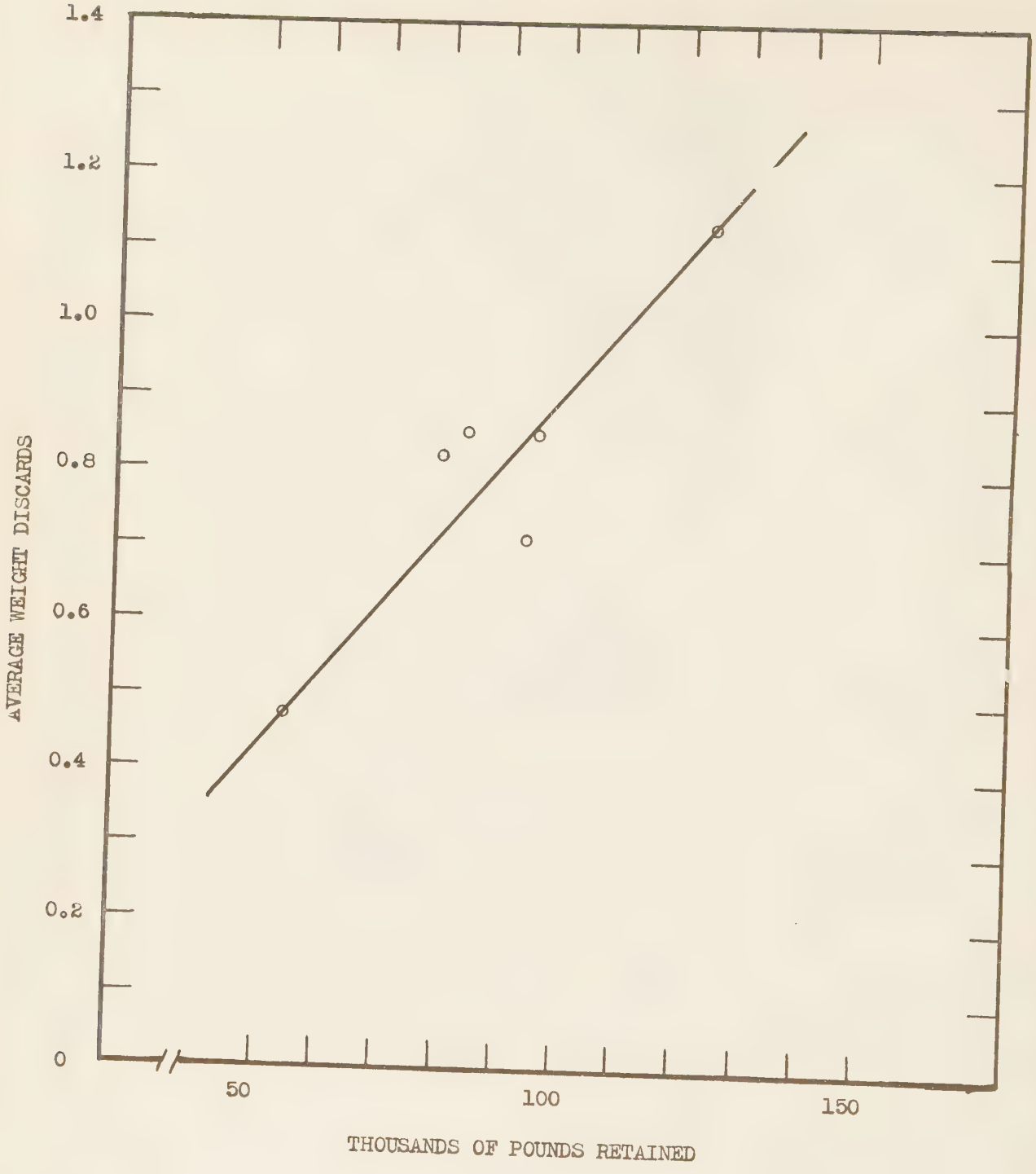

Figure 8.--Regression of average weight of discards against total pounds landed.

TABLE 3.--Percent of total haddock catch (in pounds) discarded on the commercial sea sampling trips to Georges Bank observed in 1951

Trip No.	Pounds caught	Pounds discarded	Percent discarded
51-1	58,900	4,900	8.3
51-2	79,000	0	0.0
51-3	82,010	2,010	2.4
51-4	104,155	7,755	7.4
51-5	114,385	19,685	17.2
51-6	134,225	9,525	7.1
51-7	86,733	2,733	3.2
Total	659,408	46,608	7.1
Average trip	94,201	6,658	7.1

TABLE 4.--Percent of total haddock catch (in numbers) discarded on the commercial sea sampling trips to Georges Bank observed in 1951

Trip No.	Number caught	Number discarded	Percent discarded
51-1	40,184[1/]	10,514	26.2
51-2	33,331	0	0.0
51-3	41,744	2,463	5.9
51-4	59,639	9,073	15.2
51-5	72,186	28,135	39.0
51-6	74,055	8,404	11.3
51-7	44,728	3,213	7.2
Total	365,867	61,802	16.9
Average trip	52,267	8,828	16.9

1/ No samples of the landed portion of the haddock catch were taken at sea on this trip. To derive numbers from the total pounds landed, the average weight per fish was determined from port sampling at Boston (1.82 pounds per fish).

TABLE 5.--Average weight (in pounds) of haddock on commercial sea sampling trips to Georges Bank observed in 1951

Trip No.	Pounds caught	Numbers caught	Average weight per fish caught	Pounds discarded	Numbers discarded	Average weight per fish discarded	Pounds landed	Numbers landed	Average weight per fish landed
51-1	58,900	40,184	1.46	4,900	10,514	0.47	54,000	29,670	1.82
51-2	79,000	33,331	2.37	0	0	----	79,000	33,331	2.37
51-3	82,010	41,744	1.96	2,010	2,463	0.82	80,000	39,281	2.04
51-4	104,155	59,639	1.75	7,755	9,073	0.85	96,400	50,566	1.91
51-5	114,385	72,186	1.58	19,685	28,135	0.71	94,700	44,051	2.15
51-6	134,225	74,055	1.81	9,525	8,404	1.13	124,700	65,651	1.90
51-7	86,733	44,728	1.94	2,733	3,213	0.85	84,000	41,515	2.02
Total	659,408	365,867	1.80	46,608	61,802	0.75	612,800	304,065	2.02
Average trip	94,201	52,267	1.80	6,658	8,828	0.75	87,543	43,438	2.02

The average weights of individual fish taken on each of the seven trips are shown in table 5. The average weight of haddock caught on these trips was 1.80 pounds, with individual trips ranging from 1.46 to 2.37 pounds. The average weight of fish discarded for all trips was 0.75 pounds, while on individual trips it varied from 0.47 to 1.13 pounds. The average weight per fish landed was 2.02 pounds, while on individual trips it ranged from 1.82 to 2.37 pounds.

Size composition

The size composition of haddock on the average Georges Bank trip observed in 1951 is shown in table 6 and figure 9.

The size of haddock caught on these trips ranged from 0.1 to 8.4 pounds (6 to 30 inches) with over 90 percent from 0.5 to 3.1 pounds in weight (11 to 21 inches in length).

The size of fish discarded ranged from 0.1 to 2.2 pounds (6 to 18 1/2 inches), with about 90 percent from 0.3 to 1.0 pound in weight (9 1/2 to 14 inches in length).

The sizes in the landed portion ranged from 0.6 to 8.4 pounds (11 1/2 to 30 inches), with about 90 percent from 1.1 to 2.7 pounds in weight (14 1/2 to 20 inches in length).

Cull by fishermen

Of the total catch, about 16 percent by number (7 percent by weight) was discarded, while 84 percent by number (93 percent by weight) was landed.

A major consideration in selecting a mesh size for regulation of the Georges Bank fishery has been the selection of a mesh which would release most of the sizes of haddock at present discarded at sea. Therefore, it was of considerable importance to determine the numbers of each size discarded, relative to the total numbers of that size caught.

The data pertinent to these determinations are included in table 6. The numbers caught, as well as the numbers landed and discarded of each size, also are shown in figure 9. From this figure certain percentage discard points can be determined. The 50 percent point, that is, that size at which the same number are discarded as are landed, is 0.94 pounds (about 13 3/4 inches). This is the point where the line representing discards crosses the line representing landings. From this point downward,

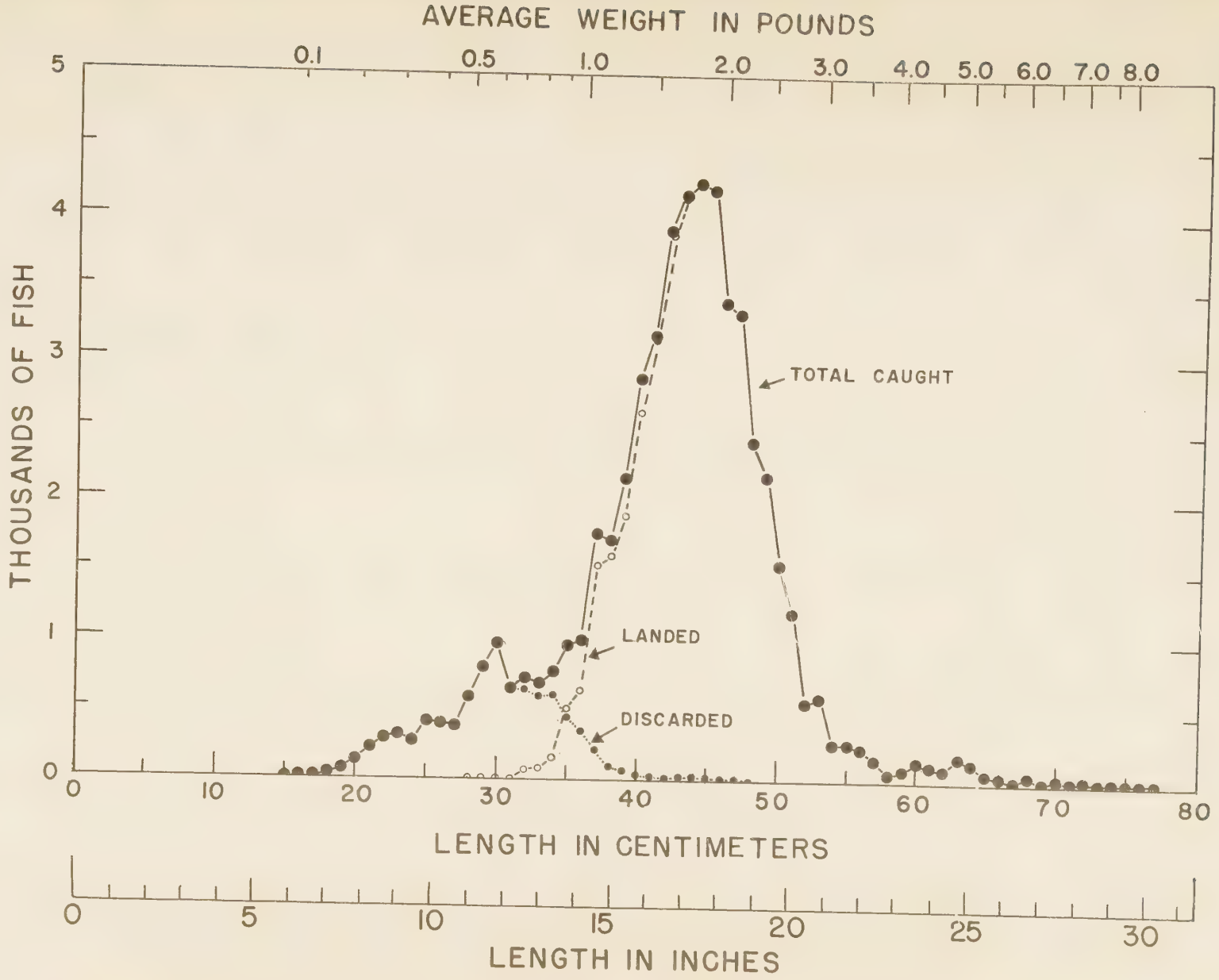

Figure 9.--Size composition on the average Georges Bank trip observed in 1951.

TABLE 6.--Size composition of fish caught, fish landed and fish discarded. [Average of observed trips in 1951. A sample of the landed portion of the catch was taken on 6 of the 7 trips. Derivation of numbers landed is based on 6 trips, while numbers discarded is based on 7 trips.]

Length in cms.	Inches	Average weight (gutted) in pounds	Numbers caught	Numbers discarded	Numbers landed	Percent discarded	Percent landed
16	6.3	0.10	5	5		100.0	0.0
17	6.7	0.12	8	8		100.0	0.0
18	7.1	0.14	40	40		100.0	0.0
19	7.5	0.17	62	62		100.0	0.0
20	7.9	0.19	135	135		100.0	0.0
21	8.3	0.22	219	219		100.0	0.0
22	8.7	0.25	282	282		100.0	0.0
23	9.1	0.29	348	348		100.0	0.0
24	9.4	0.32	306	306		100.0	0.0
25	9.8	0.36	443	443		100.0	0.0
26	10.2	0.40	393	393		100.0	0.0
27	10.6	0.45	382	382		100.0	0.0
28	11.0	0.50	583	583		100.0	0.0
29	11.4	0.55	801	789	12	98.5	1.5
30	11.8	0.61	962	959	3	99.7	0.3
31	12.2	0.67	650	650		100.0	0.0
32	12.6	0.73	726	650	76	89.5	10.5
33	13.0	0.79	686	601	85	87.6	12.4
34	13.4	0.87	777	616	161	79.3	20.7
35	13.8	0.94	960	451	509	47.0	53.0
36	14.2	1.0	993	351	642	35.3	64.7
37	14.6	1.1	1,748	221	1,527	12.6	87.4
38	15.0	1.2	1,700	107	1,593	6.1	93.9
39	15.4	1.3	1,946	66	1,880	3.4	96.6
40	15.8	1.4	2,661	39	2,622	1.5	98.5
41	16.1	1.5	3,161	33	3,128	1.0	99.0
42	16.5	1.6	3,899	15	3,884	0.4	99.6
43	16.9	1.7	4,156	25	4,131	0.6	99.4
44	17.3	1.8	4,235	25	4,210	0.6	99.4
45	17.7	1.9	4,189	11	4,178	0.3	99.7

Length in cms.	Inches	Average weight (gutted) in pounds	Numbers caught	Numbers discarded	Numbers landed	Percent discarded	Percent landed
46	18.1	2.0	3,389	9	3,380	0.3	99.7
47	18.5	2.2	3,310	4	3,306	0.1	99.9
48	18.9	2.3	2,403		2,403	0.0	100.0
49	19.3	2.4	2,156		2,156	0.0	100.0
50	19.7	2.6	1,544		1,544	0.0	100.0
51	20.1	2.7	1,192		1,192	0.0	100.0
52	20.5	2.9	549		549	0.0	100.0
53	20.9	3.1	588		588	0.0	100.0
54	21.3	3.2	262		262	0.0	100.0
55	21.7	3.4	262		262	0.0	100.0
56	22.1	3.5	230		230	0.0	100.0
57	22.4	3.7	152		152	0.0	100.0
58	22.8	3.9	62		62	0.0	100.0
59	23.2	4.1	77		77	0.0	100.0
60	23.6	4.3	141		141	0.0	100.0
61	24.0	4.5	112		112	0.0	100.0
62	24.4	4.7	91		91	0.0	100.0
63	24.8	4.9	171		171	0.0	100.0
64	25.2	5.2	126		126	0.0	100.0
65	25.6	5.4	55		55	0.0	100.0
66	26.0	5.6	49		49	0.0	100.0
67	26.4	5.9	20		20	0.0	100.0
68	26.8	6.1	55		55	0.0	100.0
69	27.2	6.4	16		16	0.0	100.0
70	27.6	6.7	28		28	0.0	100.0
71	28.0	6.9	9		9	0.0	100.0
72	28.3	7.2	24		24	0.0	100.0
73	28.7	7.5	8		8	0.0	100.0
74	29.1	7.8	14		14	0.0	100.0
75	29.5	8.1	7		7	0.0	100.0
76	29.9	8.4	2		2	0.0	100.0
Total			54,560	8,828	45,732	16.2	83.8

TABLE 7.--Cull by fishermen on the individual Georges Bank trips observed in 1951 1/

Length in centimeters	Average weight (gutted) in pounds	Percent of total catch landed Trip number				
		51-3	51-4	51-5	51-6	51-7
Under 28	0.50 and under	0.0	0.0	0.0	0.0	0.0
29	0.55	0.0	0.0	0.0	24.6	0.0
30	0.61	0.0	3.5	0.0	0.0	0.0
31	0.67	0.0	0.0	0.0	0.0	0.0
32	0.73	0.0	0.0	5.1	12.1	8.5
33	0.79	55.1	1.7	0.0	0.0	17.7
34	0.87	0.0	15.0	0.0	19.8	36.2
35	0.94	62.7	23.4	31.9	34.1	66.8
36	1.0	74.8	59.8	51.8	29.7	89.8
37	1.1	93.5	73.6	82.2	72.1	96.0
38	1.2	96.0	89.0	97.3	87.0	96.3
39	1.3	98.8	94.8	99.4	88.1	97.3
40	1.4	99.5	97.2	100.0	95.2	98.8
41	1.5	100.0	97.8	100.0	96.9	99.7
42	1.6	100.0	99.5	100.0	98.6	100.0
43	1.7	100.0	99.6	100.0	97.6	100.0
44	1.8	100.0	100.0	100.0	97.2	100.0
45	1.9	100.0	99.9	100.0	98.8	100.0
46	2.0	100.0	100.0	100.0	98.9	100.0
47	2.2	100.0	100.0	100.0	99.5	100.0
48 and over	2.3 and over	100.0	100.0	100.0	100.0	100.0

1/ Trip No. 51-1 - No sample of landed portion of catch.
Trip No. 51-2 - No discard reported.

progressively larger percentages were discarded, until at sizes below 0.5 pound (11 inches) all were discarded. Conversely, going from the 50 percent point upward toward larger sizes of fish, the percentage of discard decreased, until at the size of 2.3 pounds (19 inches) none were discarded.

This culling by the fishermen is shown more clearly by the "cull curve" (fig. 10) in which the size of fish is plotted against the percentage of catch landed.

The sizes discarded and landed varied from trip to trip as indicated previously. The cull curves for each applicable trip are presented in figure 11; the data are given in table 7.

Age composition

The age composition of haddock on the average Georges Bank trip observed in 1951 is presented in table 8. The percentage of each age discarded is given in table 9.

In 1951, the 1948 year class (3-year-olds) dominated the fishery; over 70 percent of the haddock caught were from this one year class. Next in importance was the 1949 year class (2-year-olds), which contributed about 18 percent to the total catch. All other year classes were relatively less important.

Most of the discarded haddock (66 percent) were from the 1949 year class (2-year-olds). The 1950 year class (1-year-olds) was next in importance, contributing about 27 percent of the numbers discarded. The rest of the discarded fish (about 7 percent) were from the 1948 year class (3-year-olds).

Of the landed fish, about 83 percent were from the 1948 year class (3-year-olds), 9 percent from the 1949 year class (2-year-olds), and the rest (8 percent) from other year classes.

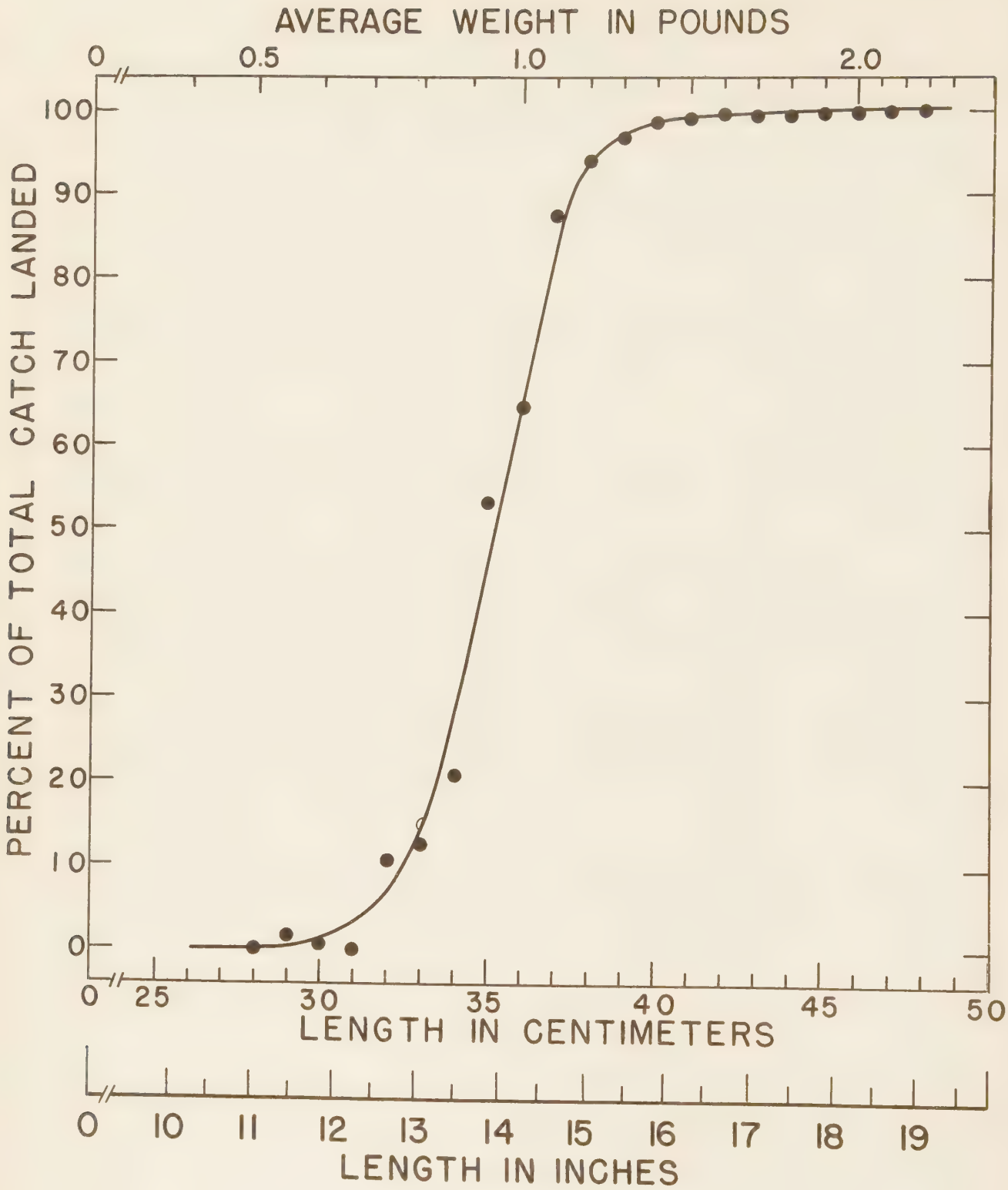

Figure 10.--Haddock cull curve on the average Georges Bank trip observed in 1951.

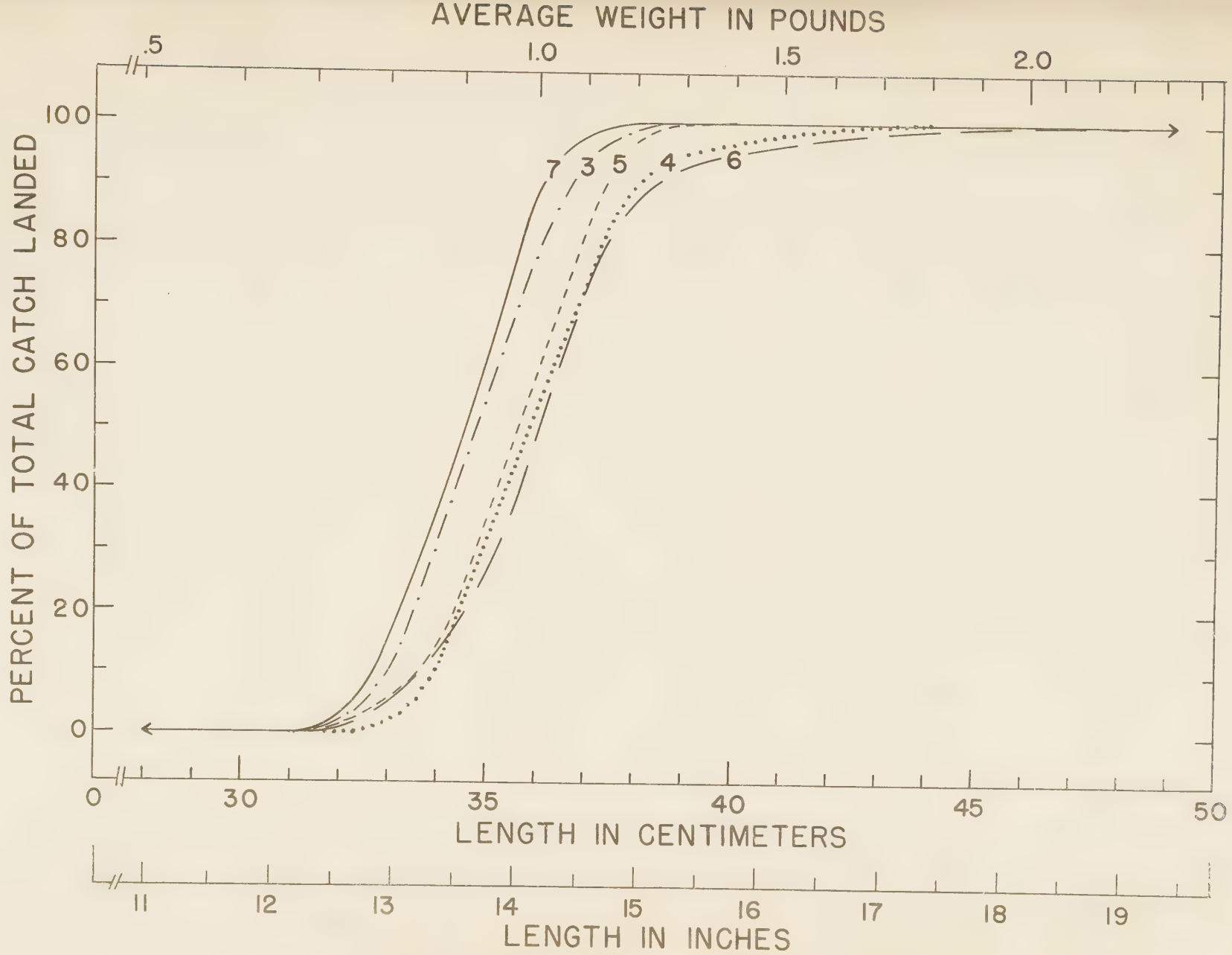

Figure 11.--Cull by fishermen on the individual Georges Bank trips observed in 1951.

TABLE 8.--Age composition of haddock on the average Georges Bank trip observed in 1951

Age in years	Year spawned	Numbers caught	Percent of total catch	Numbers discarded	Percent of total discard	Numbers landed	Percent of total landings
1	1950	2,395	4.4	2,394	27.1	1	----
2	1949	9,991	18.3	5,803	65.7	4,188	9.2
3	1948	38,476	70.5	631	7.2	37,845	82.7
4	1947	2,011	3.7	0	0.0	2,011	4.4
5	1946	1,358	2.5	0	0.0	1,358	3.0
6+	1945 and earlier	329	0.6	0	0.0	329	0.7
Total		54,560	100.0	8,828	100.0	45,372	100.0

Size composition of ages

The effect of culling on the different ages of haddock is shown more graphically by the size composition of the ages in the discarded and landed portions of the catch. These size compositions are presented in table 10 and figure 12. Referring to figure 12, the dominance of the 1948 year class in the landings is strikingly evident. Also clearly shown is the division of the 1949 year class between the discards and the landed fish, with the smaller of these being rejected and the larger included in the marketed group.

The size composition curve for the 1949 year class as shown for the total catch is markedly different from that of other year classes in that it exhibits two definite widely separated peaks. At first, it was thought that this might be due to sampling errors, but examination of this same year class a year later (in 1952) showed this same type of size distribution. The reason for this unusual size distribution of the 1949 year class cannot be explained at this time.

TABLE 9.--Percentage of each age discarded on the average Georges Bank trip observed in 1951

Age in years	Year spawned	Number caught	Number discarded	Percent discarded
1	1950	2,395	2,394	99.96
2	1949	9,991	5,803	58.08
3	1948	38,476	631	1.64
4	1947	2,011	0	0.00
5	1946	1,358	0	0.00
6+	1945 and earlier	329	0	0.00

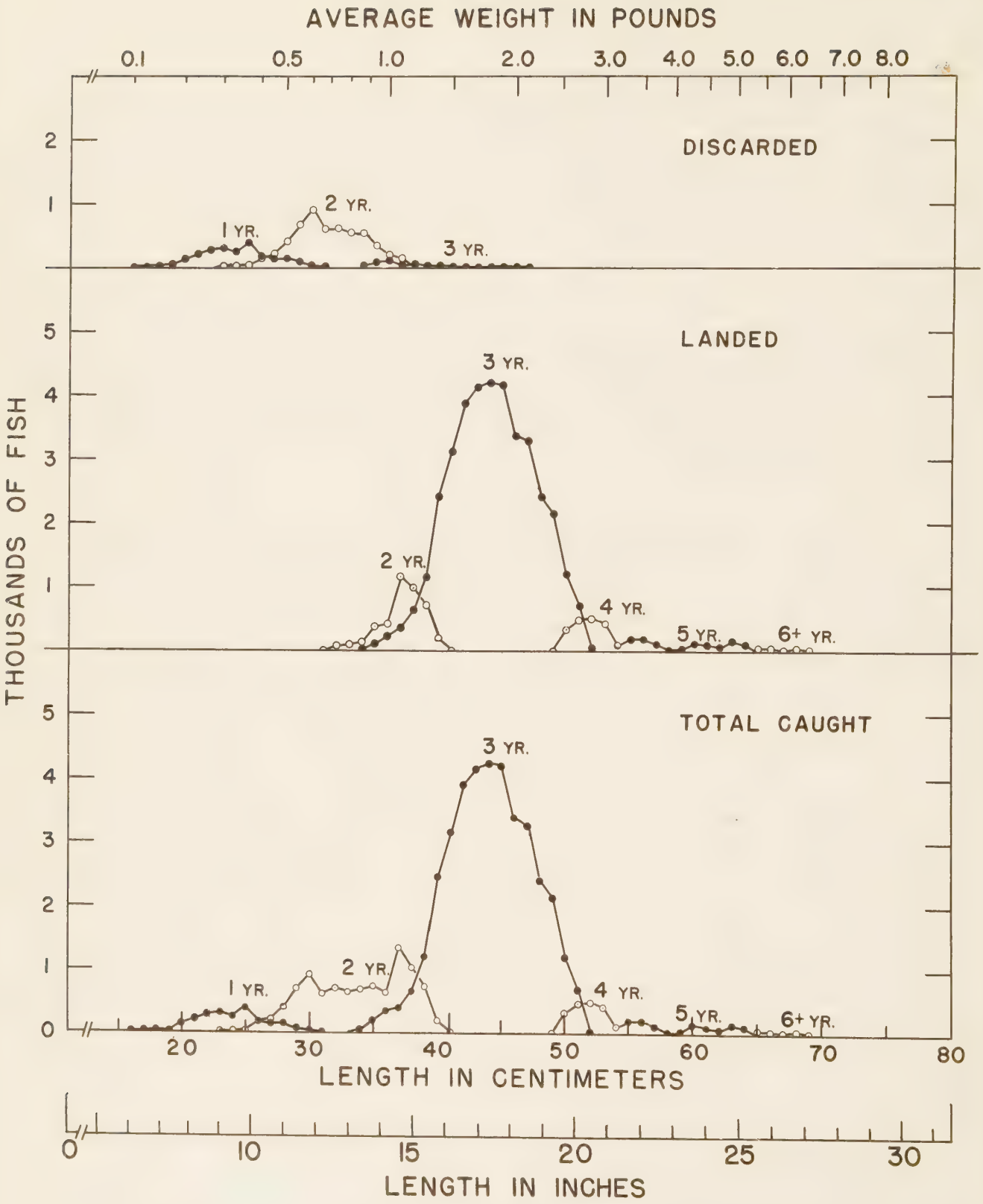

Figure 12.--Size composition of each age in catch on the average Georges Bank trip observed in 1951.

TABLE 10.--Size composition of each age in the catch on the average Georges Bank trip observed in 1951

Length in centimeters	Average weight (gutted) in pounds	Age and year class: Total catch 1 1950	2 1949	3 1948	4 1947	5 1946	6+ 1945 & earlier	Discards 1 1950	2 1949	3 1948	Landings 1 1950	2 1949	3 1948	4 1947	5 1946	6+ 1945 & earlier
16	0.10	5						5								
17	0.12	8						8								
18	0.14	40						40								
19	0.17	62						62								
20	0.19	135						135								
21	0.22	219						219								
22	0.25	282						282								
23	0.29	313	35					313	35							
24	0.32	266	40					266	40							
25	0.36	395	48					395	48							
26	0.40	194	199					194	199							
27	0.45	151	231					151	231							
28	0.50	158	425					158	425							
29	0.55	99	702					98	691		1	11				
30	0.61	39	923					39	920			3				
31	0.67	29	621					29	621							
32	0.73		708	18					632	18		76				
33	0.79		654	32					569	32		85				
34	0.87		704	73					562	54		142	19			
35	0.94		751	209					362	89		389	120			
36	1.00		640	353					223	128		417	225			
37	1.10		1,353	395					177	44		1,176	351			
38	1.20		1,023	677					45	62		978	615			
39	1.30		737	1,209					23	43		714	1,166			
40	1.40		197	2,464						39		197	2,425			

TABLE 10.--Size composition of each age in the catch on the average Georges Bank trip observed in 1951 Continued

Length in centimeters	Average weight (gutted) in pounds	Total catch						Age and year class Discards			Landings					
		1 1950	2 1949	3 1948	4 1947	5 1946	6+ 1945 & earlier	1 1950	2 1949	3 1948	1 1950	2 1949	3 1948	4 1947	5 1946	6+ 1945 & earlier
41	1.50			3,161												
42	1.60			3,899						33			3,128			
43	1.70			4,156						15			3,884			
44	1.80			4,235						25			4,131			
45	1.90			4,189						25			4,210			
										11			4,178			
46	2.00			3,389												
47	2.20			3,310						9			3,380			
48	2.30			2,403						4			3,306			
49	2.40			2,156									2,403			
50	2.60			1,210	334								2,156			
													1,210	334		
51	2.70			714	478											
52	2.90			47	502								714	478		
53	3.10			73	433	82							47	502		
54	3.20			51	91	120							73	433	82	
55	3.40			43	32	187							51	91	120	
													43	32	187	
56	3.50			10	32	188										
57	3.70				30	122							10	32	188	
58	3.90				26	36								30	122	
59	4.10				32	45								26	36	
60	4.30				21	120								32	45	
														21	120	
61	4.50					109	3									
62	4.70					88	3								109	3
63	4.90					156	15								88	3
64	5.20					105	21								156	15
65	5.40						55								105	21
																55

TABLE 10.--Size composition of each age in the catch on the average Georges Bank trip observed in 1951 Continued

Length in centimeters	Average weight (gutted) in pounds	Age and year class: Total catch 1 1950	2 1949	3 1948	4 1947	5 1946	6+ 1945 & earlier	Discards 1 1950	2 1949	3 1948	Landings 1 1950	2 1949	3 1948	4 1947	5 1946	6+ 1945 & earlier
66	5.60						49									49
67	5.90						20									20
68	6.10						55									55
69	6.40						16									16
70	6.70						28									28
71	6.90						9									9
72	7.20						24									24
73	7.50						8									8
74	7.80						14									14
75	8.10						7									7
76	8.40						2									2
Total		2,395	9,991	38,476	2,011	1,358	329	2,394	5,803	631	1	4,188	37,845	2,011	1,358	329

SUMMARY

1. During the period 1947 to 1951, the annual destruction of undersized haddock on Georges Bank by the Boston fleet alone averaged over 4 1/2 million pounds (based on skippers' estimates as reported to port interviewers). This quantity represented over 6 million individual fish.

2. Most of the destruction occurred between the months of June and October during which time most of the 2-year-old fish, which were caught in great numbers, were under 1 pound in weight and unmarketable.

3. The areas of greatest discard were the Northern Edge and Southeast Part. Areas of lesser destruction were the western side and the southern end of South Channel. Areas of most intense discard coincided with areas of most intense fishing.

4. During 1951, observers went to sea on seven commercial trips to analyze the catch. Skippers' estimates of pounds discarded were found to be within 12 percent of estimates made by the Service observers at sea.

5. The size of fish discarded varies with the size of the catch. Smaller fish are saved when the catches are small. The 50-percent point on the average cull curve was 13 3/4 inches (0.9 pounds). Practically all fish of this size were 2 years old. The smaller fish discarded included many 1-year-olds while the largest individuals in the discards included many 3-year-olds.

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SEA LAMPREY SPAWNING:
Wisconsin and Minnesota Streams Of Lake Superior

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 97

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Explanatory Note

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State or cooperating Agencies and in processed form for economy and to avoid delay in publication.

Washington,D. C.
June, 1953

United States Department of the Interior, Douglas McKay, Secretary
Fish and Wildlife Service, John L. Farley, Director

SEA LAMPREY SPAWNING: WISCONSIN AND MINNESOTA STREAMS OF LAKE SUPERIOR

by

Howard A. Loeb
Fishery Biologist

Special Scientific Report: Fisheries No. 97

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The 1952 sea lamprey stream survey in the Lake Superior Basin was organized as a continuation of the 1950-51 survey. Immediate objectives during the 1952 season were as follows:

1. To extend the surveyed area to include all Wisconsin and Minnesota watersheds in the Lake Superior basin.

2. To identify further, those streams which are producing or may produce sea lampreys in the future.

3. To determine the general characteristics of those streams in which control measures may be required.

The standards and methods used in 1952 differed from those of 1950 and 1951 only in that the stream examinations were less intensive (Loeb and Hall, 1952).

All of the streams in Minnesota (Cook, Lake, and St. Louis Counties) and a portion of those in Wisconsin (Iron, Ashland, and Bayfield Counties) were surveyed. In addition, all of the streams on Grand Island, Alger County, Michigan, were examined.

The Wisconsin streams were examined during the month of June. Operations in Minnesota began on July 11 and terminated on August 8.

Personnel included, in addition to the author, Clifford Brynildson, Robert Braem, Earl Schaedig, and George Simmons. The map of Iron County, Wisconsin was prepared by Bernard Smith. All other maps are the work of Robert Braem.

Appreciation is extended to the Minnesota Department of Fish and Game for data concerning the North Shore watersheds, and to the Wisconsin Conservation Department for the offer of their patrol boat for the survey of inaccessible streams.

FIGURE 1. LAKE SUPERIOR, SHOWING AREAS SURVEYED IN 1950, 1951, AND 1952

Examination of streams on Grand Island

Of 23 streams on the island, 21 cannot be utilized by sea lampreys because of one or more of the following limiting factors: small size, low temperatures, and the presence of bedrock barriers ranging from 8 to 100 feet in height.

North Light Creek (at the northern end of the island), a stream approximately 3 miles in length, flows from a tag alder swamp and is soft bottomed throughout; this stream is unsuitable for spawning lampreys due to a lack of spawning gravel.

Echo Lake Creek (T 47 N, R 19 W, S 4, on the western side of the island), the outlet of Echo Lake, is approximately 1/2 mile in length, 10 to 15 feet in width, and up to 10 inches in depth. Water temperature on June 21 was 60° F. Spawning medium for 25 or more nests is present. Sea lampreys can be blocked from this stream by a 25-foot wide concrete barrier placed at the mouth. Power lines are present only at the south end of the island, a distance of at least 3 miles. The stream can be reached by automobile. The proposed weir site is approximately 300 feet from the road.

Examination of streams in Wisconsin

Iron County: Contains 8 small streams (Fig. 2), 4 of which can probably be utilized by sea lampreys (Table 1). The productive potentials of the latter range from small to medium (Loeb and Hall, 1952). Electrical control devices are recommended.

All of the streams are subject to rapid fluctuations in water levels and several to a resulting heavy turbidity. Bottom irregularity and scouring by sudden freshets may limit the extent of utilization by sea lampreys even in the streams considered to have a productive potential.

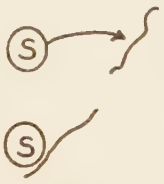
Installation and operation of control devices will be hindered by the relative inaccessibility of two streams, and by occasional excessive turbidity (lake clay).

Ashland County: Contains 11 watersheds (Fig. 3), 5 of which have productive potentials ranging from small to large (Table 2).

The condition of Denomie Creek could not be determined because of continual heavy turbidity, and the Kakagon River and Wood Creek Slough were incompletely examined for the same reason. Heavy and continual turbidity also prevented the survey of the main portion of the Bad River except in the portion between the mouth and U. S. Highway 2; spawning habitat was found in three tributaries, however, during a brief period when they were clear.

LEGEND FOR FIGURES 2-6

SPAWNING HABITAT



NATURAL BARRIER

MAN-MADE BARRIER

BASE MAPS — STATE HIGHWAY COMMISSION OF WISCONSIN

ST. LOUIS CO. HIGHWAY DEPT

OFFICIAL MAP OF LAKE CO.

OFFICIAL MAP OF COOK CO.

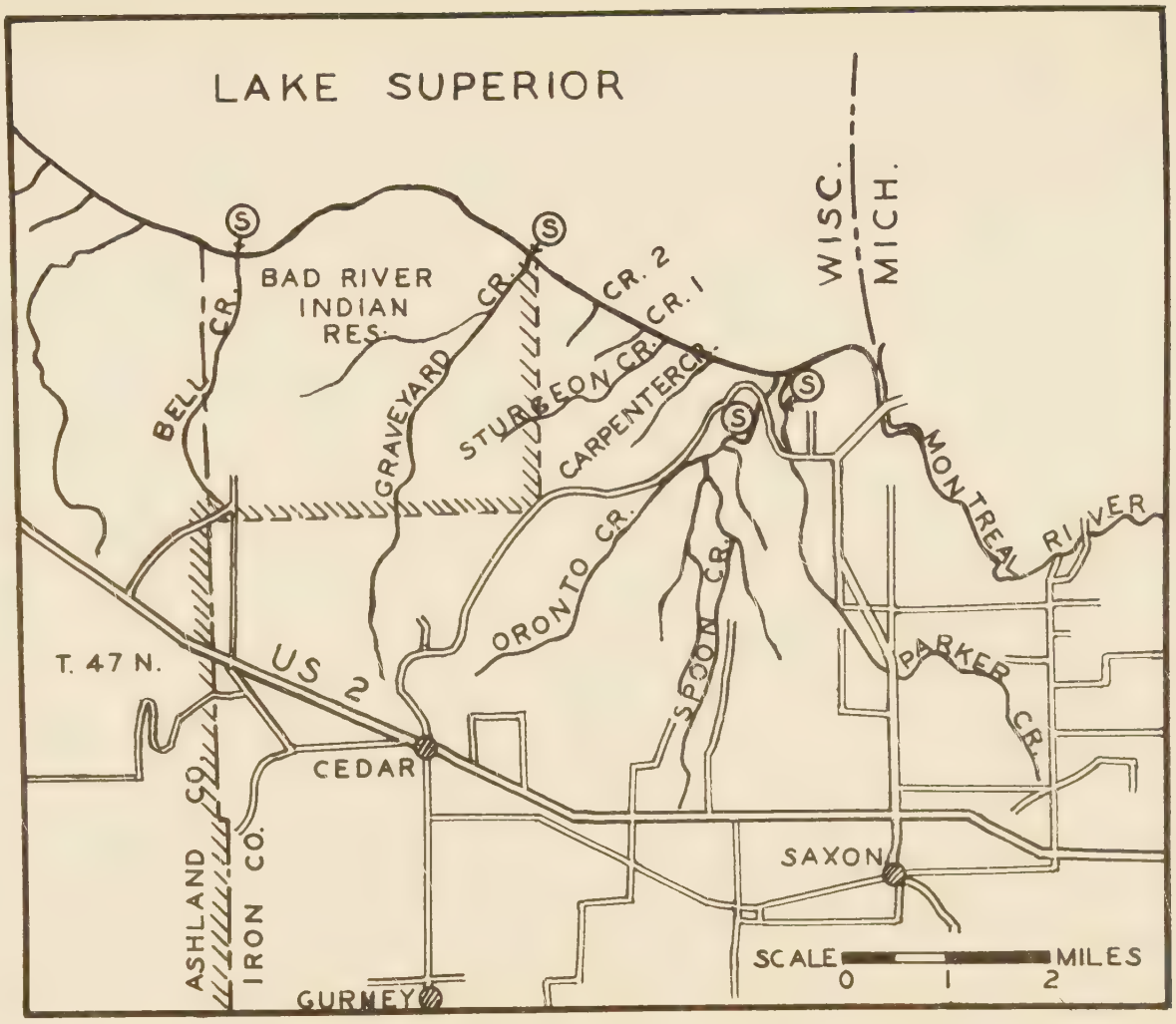


FIGURE 2. SHORELINE OF IRON COUNTY, WISCONSIN

Table 1.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Iron County, Wisconsin
(Survey made in 1952)

Name of stream 1/ and mouth location	Total length in mi.	Aver. width feet 2/	Aver. depth feet 2/	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Parker Cr. 47N-1W-12	13	4	0.3	60 (6-10)	Small	Drying, scouring, water level fluctuations, temporary barrier at mouth, irregular bottom	---	24' electrical device 150' above mouth; power lines within 150'
Oronto Cr. 47N-1W-12	30	10	0.5	68 (6-10)	Small	Drying, scouring, water level fluctuations, irregular bottom	---	24' electrical device at bridge 0.1 miles above mouth; power lines within 25'
Graveyard Cr. 47N-1W-9	10	10?	1.0?	--- (6-11)	Small	Drying, scouring, water level fluctuations	---	Relatively inaccessible; barrier control unlikely
Bell Cr. 47N-1W-6	3	5	0.3	63 (6-11)	Medium	Water level fluctuations, irregular bottom	---	25' electrical device, 200' above mouth; power lines not available; relatively inaccessible

1/ List includes only those streams which appear to have a productive potential.

2/ Applicable only to the surveyed portion of the stream.

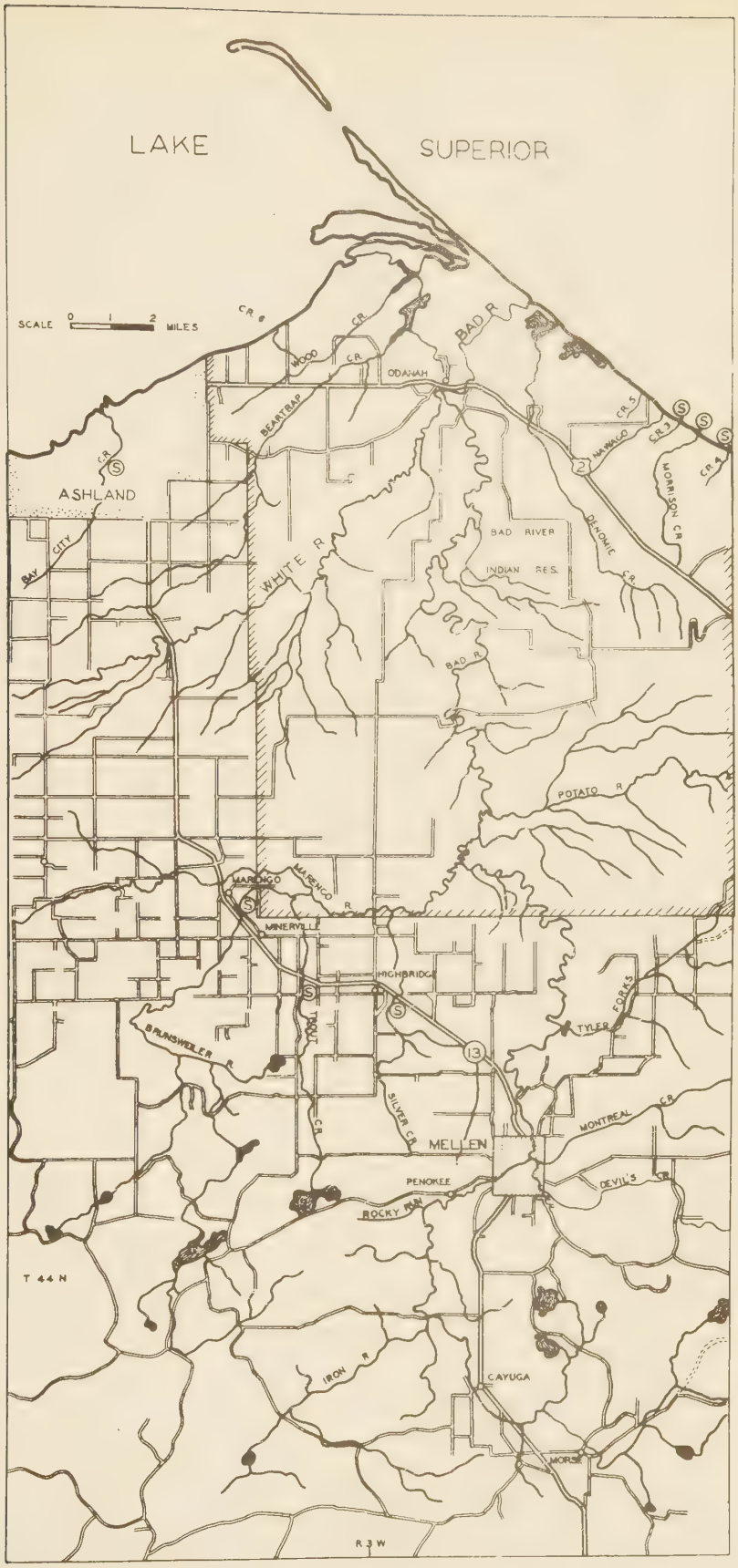


FIGURE 3. SHORELINE OF ASHLAND COUNTY, WISCONSIN

Table 2.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Ashland County, Wisconsin
(Survey made in 1952)

Name of stream 1/ and mouth location	Total length in mi.	Aver. width feet 2/	Aver. depth feet 2/	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 4 47N-2W-1	2	3	0.3	64 (6-11)	Small	Small size, occasionally blocked at mouth by sand bar	---	12' electrical device 100' above mouth; relatively inaccessible
Morrison Cr. 48N-2W-36	10	8	0.4	59 (6-11)	Medium	Lowering of water level, blocking of mouth by sand bar	---	50' electrical device 200' above mouth; relatively inaccessible
Creek No. 3 48N-2W-35	2	2	0.3	60 (6-11)	Small	Small size	---	16' electrical device 150' above mouth; relatively inaccessible
Denomie Cr. 48N-2W-20	12	10	---	59 (6-18)	---	---	?	Stream not completely checked because of continual turbidity
Bad R. system 48N-2W-17	100+	250	10.0	66 (6-18)	Large	---	?	290' electrical device at highway bridge 4 miles above mouth; control difficult due to large size, almost continual turbidity, and run of walleye used by Indians

Table 2, continued

Name of stream 1/ and mouth location	Total length in mi.	Aver. width feet 2/	Aver. depth feet 2/	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Kakagon R. system 48N-3W-11	40	40	---	63-66 (6-18)	---	Low velocity	---	System not completely checked because of continual turbidity
Wood Cr. Slough 48N-3W-11	12	10	---	59 (6-18)	---	Low velocity	---	Stream not completely checked because of continual turbidity
Bay City Cr. 47N-4W-33	10	6	0.4	60 (6-18)	Small	Low velocity, low water levels	---	Stream not completely checked because of continual turbidity

1/ List includes only those streams which appear to have a productive potential.

2/ Applicable only to the surveyed portion of the stream.

As judged from the rocky character of the Bad River watershed, the main river and its larger tributaries such as the White, Narengo, and Potato Rivers probably contain large amounts of spawning habitat. Complete and partial barriers may be present in relatively inaccessible areas.

Electrical control devices are recommended for all streams with a productive potential. Control will be rendered difficult due to the relative inaccessibility of Morrison Creek and Creeks 3 and 4, to the large size of the Bad River, and to the high degree of turbidity of several of the streams.

Bayfield County: A total of 10 streams was surveyed, but examination was incomplete because of almost continual heavy turbidity. Several of these streams can probably be utilized by sea lampreys. At least 25 streams were not examined because of the turbidity factor.

Douglas County: At least 38 watersheds are present; none was examined because of contimual heavy turbidity. Several can probably be utilized by sea lampreys.

Apostle Islands (Ashland County): Not examined; may contain several small streams suitable for sea lamprey spawning.

Almost all of the Wisconsin streams flowing into Lake Superior are affected by rapid fluctuations in water levels and extremely heavy turbidity (lake clay). The latter condition appears to accompany even light rains, and as a result the streams are often turbid for weeks.

Thr present study was greatly hindered by both conditions. Only limited portions of the larger watersheds could be examined, and these relatively ineffectually. Adult lampreys and nests, if present, were of course, not observed. Stream bottoms were visible only in isolated instances. The turbid condition could well account for the lack of reports concerning sea lamprey spawning along the Wisconsin shoreline.

Electrical control techniques are practical in these streams, but construction, operation, and maintenance will be impeded by both turbidity and water level fluctuations. It is recommended that an effort be made to determine the bottom conditions of the remaining streams only during the periods when they are clear, and that mechanical control devices be constructed initially on certain streams to ascertain the extent of sea lamprey spawning runs, if any.

Cook County: Contains 77 separate watersheds (Fig. 4). At least 46 of these are unsuitable for sea lamprey spawning because of the following limiting factors: low temperatures, scouring, bottom irregularity, barriers, small size, rapid fluctuations in water levels, etc.

Twenty-two streams are considered to be marginal (Table 3). Spawning gravel for a varying number of nests is present, but other factors are likely to be unfavorable enough to seriously hamper spawning efforts.

Nine streams with productive potentials ranging from medium to large are believed to be quite suitable for sea lampreys, despite the presence of limiting factors (Footnote 2, Table 3). Six of these streams are large; three others averaged 5, 8, and 15 feet in width in the sections examined. Electrical control devices are recommended for all of them.

The geology and surface features of the Cook County watershed have been described in detail in a publication of the Minnesota Department of Conservation (Smith and Moyle, 1944). Suffice it to say that most of the streams in the Cook County watershed flow over rocky, rugged terrain, often cliff-like in gradient. Barriers and partial barriers to fish are numerous. Run-off is rapid and great fluctuations in water levels are the rule. The majority of streams is small. A number of them are probably intermittent in character.

Any type of control operation will be aided by the accessibility of the majority of streams in the watershed. A few streams in the northern portion of the county are relatively inaccessible.

Installation of electrical devices will be difficult in the Pigeon and Arrowhead Rivers due to large size, reversing currents, shifting sand bars, and pulp wood operations.

Lake County: Contains 50 separate watersheds (Fig. 5). At least 13 of these are unsuitable for sea lamprey spawning because of the presence of barriers, small size, irregularity of bottom, etc.

Twenty-eight streams are considered to be marginal (Table 4). Spawning gravel for a varying number of nests is present, but other factors are likely to be unfavorable enough to impede spawning efforts.

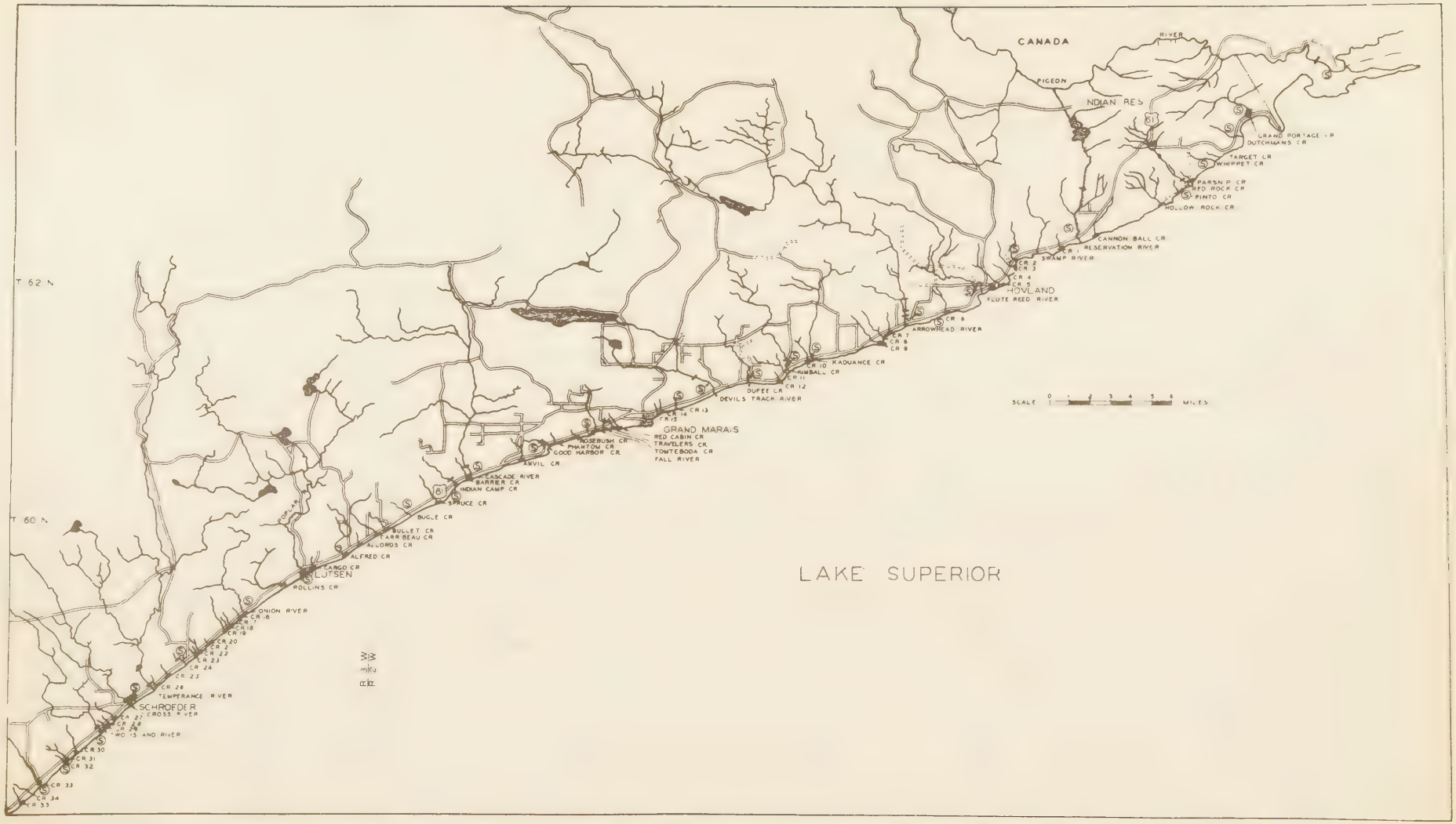


FIGURE 4. SHORELINE OF COOK COUNTY, MINNESOTA

Table 3.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Cook County, Minnesota
(Survey made in 1952)

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp, F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Pigeon R.[2] Canadian Border	40+	250	5.0?	67-70 (7-11)	Medium	None	2.0 mi.	Main spawning area in riffle area just below falls. Control difficult due to reversing current from mouth to riffle, and floating of pulp sticks over falls
Grand Portage Cr. 63N-6E-4	5+	10	0.8	57-62 (7-12)	Medium	Steep gradient, high velocity, irregular bottom, scouring, water level fluctuations	---	18' electrical device at mouth; power line within 0.25 mile
Dutchman's Cr. 63N-6E-9	4	5	0.5	54 (7-14)	Medium	Low temperature, irregular bottom, drying, scouring, water level fluctuations, partial blocking at mouth by bar	---	0.5 mile walk to 10' electrical device at mouth; power line within 0.5 mile
Whippet Cr. 63N-6E-19	3	5	0.5	53-61 (7-14)	Small	Irregular bottom, partial barriers, scouring, lack of larval habitat	---	3' x 20' concrete barrier at mouth; reached by 0.5 mile canoe ride on lake, power not available

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Red Rock Cr. 63N-5E-25	9	20	0.7	57 (7-15)	Medium	Irregular bottom, steep gradient	0.5 mi.	25' electrical device at mouth; power lines within 0.1 mile; road almost to mouth
Reservation R.[2] 62N-5E-6	16	25	1.0	61 (7-14)	Large	None	4.5 mi.	30' electrical device 50' above the mouth; power lines and road 300' above site
Creek No. 2[2] 62N-4E-10	2	8	0.5	61 (7-14)	Medium	Scouring, small size	---	25' electrical device 225' above mouth; power lines and road at site
Flute Reed R.[2] 62N-4E-20	20	15	0.8	60 (7-15)	Large	Irregular bottom, scouring	---	25' electrical device 60' above mouth; power lines and road 250' above site
Creek No. 6 62N-3E-25	3	4	0.5	56 (7-15)	Medium	Steep gradient, scouring, small size	0.2 mi.	15' electrical device 40' above mouth; power lines and road 0.2 mile above site
Arrowhead R.[2] 62N-3E-27	120	60	2.0	72 (7-15)	Medium	Steep gradient, scouring, high velocity, irregular bottom	0.75 mi.	Electrical device difficult due to width of estuary, and shifting of gravel bar at mouth
Kadunce R. 61N-2E-2	10	12	0.8	62 (7-15)	Medium	Irregular bottom, scouring, partial barrier 0.5 mile above mouth	---	25' electrical device 50' above mouth; power lines and road 100' above site

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Kimball Cr. 61N-2E-10	12	15	0.8	60 (7-17)	Medium	Irregular bottom, scouring, partial barrier 0.5 mile above mouth	---	30' electrical device 75' above mouth; power lines and road 225' above site
Dufee Cr. 61N-2E-8	8	8	0.6	63 (7-17)	Medium	Steep gradient, water level fluctuations, small size, partial barrier	---	2' x 20' concrete barrier in culvert at highway, 75' above mouth
Devil's Track R.[2] 61N-1E-13	51	30	1.0	65 (7-17)	Large	Scouring	2.0 mi.	110' electrical device, 100' above mouth; power lines 50' from site
Creek No. 13 61N-1E-22	1+	3	0.4	56 (7-17)	Medium	Low temperature, small size, scouring	---	3' x 10' concrete barrier, 50' above mouth; 0.5 mile walk downstream from highway
Fall R. 61N-1W-33	7	20	2.0	61 (7-17)	Medium	Scouring, lack of larval habitat, high velocity	200 ft.	50' electrical device (largely on sand bar) at mouth; power lines and road 0.2 mile above
Good Harbor Cr. 61N-1W-34	3	15	0.5	58 (7-17)	Medium	Submarginal spawning medium, no sand present	0.75 mi.	10' electrical device at mouth power line within 100'; road within 200'

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Cascade R. 60N-2W-1	78	50	3.0	68 (7-17)	Medium	Submarginal spawning medium, high velocity, lack of larval habitat, scouring	0.75 mi.	30' electrical device at mouth; power lines and highway at mouth
Indian Camp Cr.[2] 60N-2W-11	4	5	0.5	60 (7-17)	Medium	None	0.75 mi.	20' electrical device at mouth; power lines within several hundred yards
Bugle Cr. 60N-2W-17	2+	5	0.3	52 (7-18)	Medium	Poor larval habitat, small size, low temperature, partial barrier at mouth	---	Barrier at mouth by rock removal; power lines and road within 600'
Cargo Cr. 60N-3W-34	1	4	0.6	56 (7-18)	Small	Poor larval habitat, small size, low temperature, partial drying, partial barrier at mouth	0.5 mi.	3' x 15' concrete barrier at mouth; power lines and road within 100 yards
Poplar R. 60N-3W-33	65	50	4.0	66 (7-18)	Small	Spawning possible only on beach gravel	250 ft.	Electrical device, 50'-100' long; power lines and road at site
Onion R. 49N-4W-12	14	30	2.0	59 (7-18)	Small	Irregular bottom, high velocity, scouring	0.3 mi.	Possibly no productive potential

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 24 59N-4W-21	1	5	0.5	57 (7-18)	Medium	Small size, drying, scouring, water level fluctuations	0.5 mi.	6' electrical device; 50' above mouth; power lines and road at site
Cross R.[2] 58N-5W-1	55	30	1.0	65 (7-18)	Medium	Some scouring	0.25 mi.	50'-75' electrical device at mouth; power lines and road 150 yards
Two Island R.[2] 58N-5W-9	21	30	1.0	62 (7-18)	Medium	None	175 ft.	45' electrical device at mouth; power lines 0.25 mile; road 0.1 mile
Creek No. 30 58N-5W-15	2	4	0.25	58 (7-23)	Medium	Partial barrier at mouth, scouring, small size	---	3' x 10' concrete barrier 20' above mouth
Creek No. 31 58N-5W-16	2	4	0.3	58 (7-23)	Small	Small size, scouring, lack of larval habitat	35 ft.	3' x 10' concrete barrier at mouth; road 0.1 mile
Creek No. 32 58N-5W-16	1+	3	0.2	56 (7-23)	Small	Small size, low temperature, irregular bottom, poor spawning medium	---	3' x 7' concrete barrier at mouth; road 0.1 mile
Creek No. 33 58N-5W-29	4	4	0.4	59 (7-23)	Medium	Small size, scouring, partial barrier at mouth	0.1 mi.	3' x 20' concrete barrier at mouth; road at site

Table 3, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 34 58N-5W-29	1	2	0.3	59 (7-23)	Medium	Small size, scouring, partial barrier at mouth	---	3' x 8' concrete barrier 40' above mouth; at highway

1/ List includes only those streams which appear to have a productive potential.

2/ Stream is one of a group of 22 in Minnesota which appear to be more suited to sea lamprey spawning than the other streams with a productive potential. These streams should be closely checked for spawning in the future since they will probably be the first to be utilized.

3/ Applicable only to the surveyed portion of the stream.

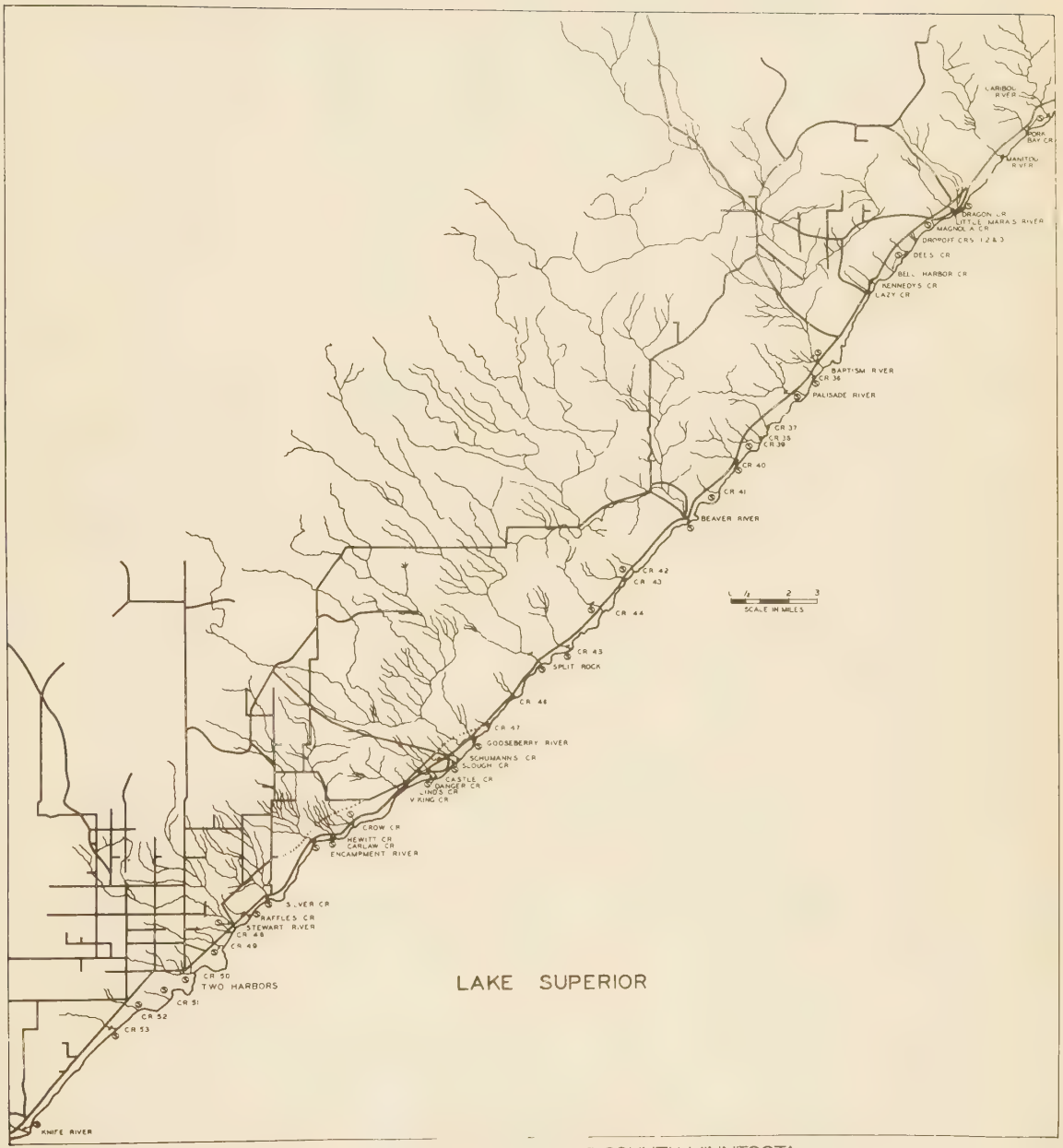


FIGURE 5. SHORELINE OF LAKE COUNTY, MINNESOTA

Table 4.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in Lake County, Minnesota
(Survey made in 1952)

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Caribou R. 58N-6W-36	40	30	0.7	61 (7-23)	Medium	Scouring, no larval habitat	200 ft.	Electric device 90' long; power lines available
Pork Bay Cr. 57N-6W-2	2	8	0.5	56 (7-23)	Medium	No larval habitat, low temperature, drying	---	25' electrical device, 50' above mouth; power lines 0.25 mile above at highway
Dragon Cr.[2] 57N-6W-16	5	10	0.7	59-60 (7-23)	Medium	None	0.3 mi.	20' electrical device, 15' above mouth; power lines at adjacent resort
Little Marais R. 57N-6W-16	4	20	0.8	62 (7-23)	Medium	Scouring, proximity of spawning habitat to mouth	0.1 mi.	20' electrical device, 30' above mouth; power lines at resort at mouth
Magnolia Cr. 57N-6W-20	0.5	5	0.3	59 (7-24)	Small	Drying, small size	---	18' electrical device at mouth; power lines at highway 400' above mouth
Dee's Cr. 57N-6W-30	1	4	0.1	56 (7-24)	Small	Drying, small size, spawning habitat at mouth, low temperature	30 ft.	---
Bell Harbor Cr. 57N-6W-31	1	10	0.5	59 (7-24)	Small	Drying, little larval habitat	---	3' x 30' concrete barrier at mouth; power lines within 300' of mouth

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Baptism R.[2] 56N-7W-15	125	40	1.0	66 (7-23)	Large	Scouring, spawning medium fair	1.25 mi.	100' electrical device 20' above mouth; power lines 600' at highway
Creek No. 36 56N-7W-15	1+	2	0.3	58 (7-24)	Medium	Scouring, small size	---	6' electrical device 50' above mouth; power lines 450'
Palisade Cr.[2] 56N-7W-22	5	7	0.5	62 (7-24)	Medium	Small size, irregular bottom	1.5 mi.	30' electrical device at mouth; power lines 0.25 mile above at highway
Creek No. 39 56N-7W-32	2	4	0.5	65 (7-24)	Medium	Small size, irregular bottom	---	16' electrical device at mouth; power lines 100' above
Creek No. 40 56N-7W-32	2	4	0.4	71 (7-24)	Small	Small size, irregular bottom	0.1 mi.	10' electrical device 50' above mouth; power lines 0.1 mile above at highway
Creek No. 41 55N-7W-7	2	2	0.3	60 (7-24)	Medium	Small size, irregular bottom and mouth	---	Possible barrier at mouth; possible electric device 75' above mouth; power lines 50' above site
Beaver R.[2] 55N-8W-12	143	30	1.5	66 (7-25)	Medium	Lake effect	0.25 mi.	60' electrical device 900' above mouth; power lines 300' above at highway; possible spawning in area of reversing current below site

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 42 55N-8W-22	1.5	3	0.1	59 (7-25)	Small	Small size, scouring, steep gradient	---	8' electrical device 20' above mouth; power lines 300'
Creek No. 44 55N-8W-33	3	7	0.4	61 (7-25)	Medium	Small size, scouring, partial barrier at mouth, irregular bottom	1.5 mi.	12' electrical device 100' above mouth; power lines 600'
Creek No. 45 54N-8W-5	5	5	0.2	65 (7-25)	Small	Small size, irregular bottom, scouring, water level fluctuations	0.2 mi.	25' electrical device 600' above mouth; power lines 0.25 mile above at highway
Split Rock R.[2] 54N-8W-7	44	20	0.7	65 (7-28)	Large	None	1.0 mi.	75' electrical device 150' above mouth; power lines 150' above site
Gooseberry R.[2] 54N-9W-22	86	125	4.0	65 (7-25)	Large	None	0.75 mi.	Control difficult due to size and reversing current
Schumanns Cr. 54N-9W-27	2	5	0.9	62 (7-25)	Small	Small size, irregular bottom	---	2' x 30' concrete barrier 60' above mouth
Slough Cr. 54N-9W-27	2.5	7	0.8	66 (7-25)	Small	Scouring, small size	1.5 mi.	20' electrical device at mouth; power lines 300'

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Castle Cr. 54N-9W-33	2.5	6	0.5	64 (7-25)	Small	Small size, irregular bottom, drying	---	Barrier at mouth
Danger Cr. 54N-9W-33	1.5	8	0.5	60 (7-28)	Medium	Small size, water level fluctuations, little larval habitat	---	16' electrical device at mouth; power lines 150'
Crow Cr. 53N-10W-1	12	50	0.5	63 (7-28)	Medium	Scouring, water level fluctuations, no larval habitat	---	65' electrical device 40' above mouth; power lines several hundred yards
Hewitt Cr. 53N-10W-12	2	5	0.5	60 (7-28)	Small	Irregular bottom, water level fluctuations, scouring, drying, small size, little larval habitat	---	3' x 18' barrier at mouth; power lines 150'
Carlaw Cr. 53N-10W-2	2	5	0.5	62 (7-28)	Small	Same	---	3' x 6' barrier at mouth; power lines 150'
Encampment R. 53N-10W-11	17	75	4.0	67 (7-28)	Medium	Reversing current in mouth area	0.25 mi.	Control difficult due to reversing current
Silver Cr.[2] 53N-10W-21	16	30	0.8	64 (7-28)	Medium	Scouring	---	70' electrical device 100' above mouth; power lines readily available; possible reversing current

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Raffles Cr. 53N-10W-28	1.5	5	0.2	60 (7-28)	Small	Irregular bottom, scouring, lack of sand and larval habitat	0.25 mi.	3' x 6' concrete barrier at mouth
Stewart R.[2] 53N-10W-29	34	20	0.5	70 (7-28)	Large	Irregular bottom	---	75' electrical device 100' above mouth; power lines 75'
Creek No. 48 53N-10W-29	1+	3	0.3	64 (7-28)	Medium	Small size, irregular bottom, scouring, drying, partial barrier	---	13' concrete barrier 60' above mouth
Creek No. 49 53N-10W-32	2	4	0.4	64 (7-28)	Medium	Small size	---	10' electrical device just above mouth; power lines 300' at highway
Creek No. 50 52N-10W-6	1+	4	0.3	60 (7-28)	Medium	Irregular bottom, small size	---	35' electrical device 50' above mouth; power lines 225' above site
Creek No. 51 52N-10W-1	2	4	0.3	57 (7-29)	Medium	Drying, partial barrier, small size	---	Concrete barrier at mouth; power lines 300'
Creek No. 52 52N-10W-11	3	2	0.1	58 (7-29)	Medium	Small size, water level fluctuations	---	12' concrete barrier 15' above mouth; power lines 0.5 mile above

Table 4, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Creek No. 53 52N-10W-15	3	3	0.3	59 (7-29)	Medium	Small size, scouring	0.1 mi.	Concrete barrier 10' above mouth; power lines 0.5 mile at highway
Knife R.[2] 52N-11W-31	94	75	2.0	64 (7-29)	Large	Partial barrier, scouring, high velocities, water level fluctuations	---	130' electrical device at highway 61; power lines at highway

1/ List includes only those streams which appear to have a productive potential.

2/ Stream is one of a group of 22 in Minnesota which appear to be more suited to sea lamprey spawning than the other streams with a productive potential. These streams should be closely checked for spawning in the future since they will probably be the first to be utilized.

3/ Applicable only to the surveyed portion of the stream.

Nine streams with productive potentials ranging from medium to large are considered quite suitable for sea lampreys, despite the presence of limiting factors (Footnote 2, Table 4). Five of these streams are large, from 30 to 125 feet in width in the areas examined. The remaining 4 streams average from 7 to 20 feet in width. Electrical control devices are recommended for all but the Gooseberry River. Control in this stream will be difficult due to its large size, and the presence of a reversing current resulting from lake seiches.

The geology, surface features, and stream characteristics of Lake County are, in general, similar to those described for Cook County.

Control operations will be aided by the relative accessibility of all streams. Installation and operation of devices will be made difficult by rapid fluctuation in water levels in almost all of the streams involved.

A number of the streams examined in Lake County would probably have been bypassed if the survey had taken place during a period of dry weather.

St. Louis County: Contains 29 streams (Fig. 6), at least 6 of which are unsuitable for sea lamprey spawning because of the presence of barriers, steep gradients, industrial wastes, etc.

Nineteen streams are considered to be marginal (Table 5). Spawning gravel for a varying number of nests is present, but other factors are likely to be unfavorable enough to obstruct spawning efforts. Several of these streams flow underground in the business district of the City of Duluth. Barriers may be present in the underground portions. The mouths of these streams are not located easily.

Nine of the streams examined flow into the St. Louis River. Twenty streams are located within the Duluth city limits.

Four streams with productive potentials ranging from medium to large are considered to be quite suitable for sea lampreys despite the presence of partial barriers, irregular bottom, and the possible limiting effects of low oxygen in the St. Louis River (Footnote 2, Table 5). Three of these streams are medium sized, averaging from 15 to 20 feet in width in the sections examined. The remaining stream averages 50 feet in width. Electrical control devices are recommended for these streams. Control in one stream will be hindered by the presence of a reversing current, resulting from lake seiches.

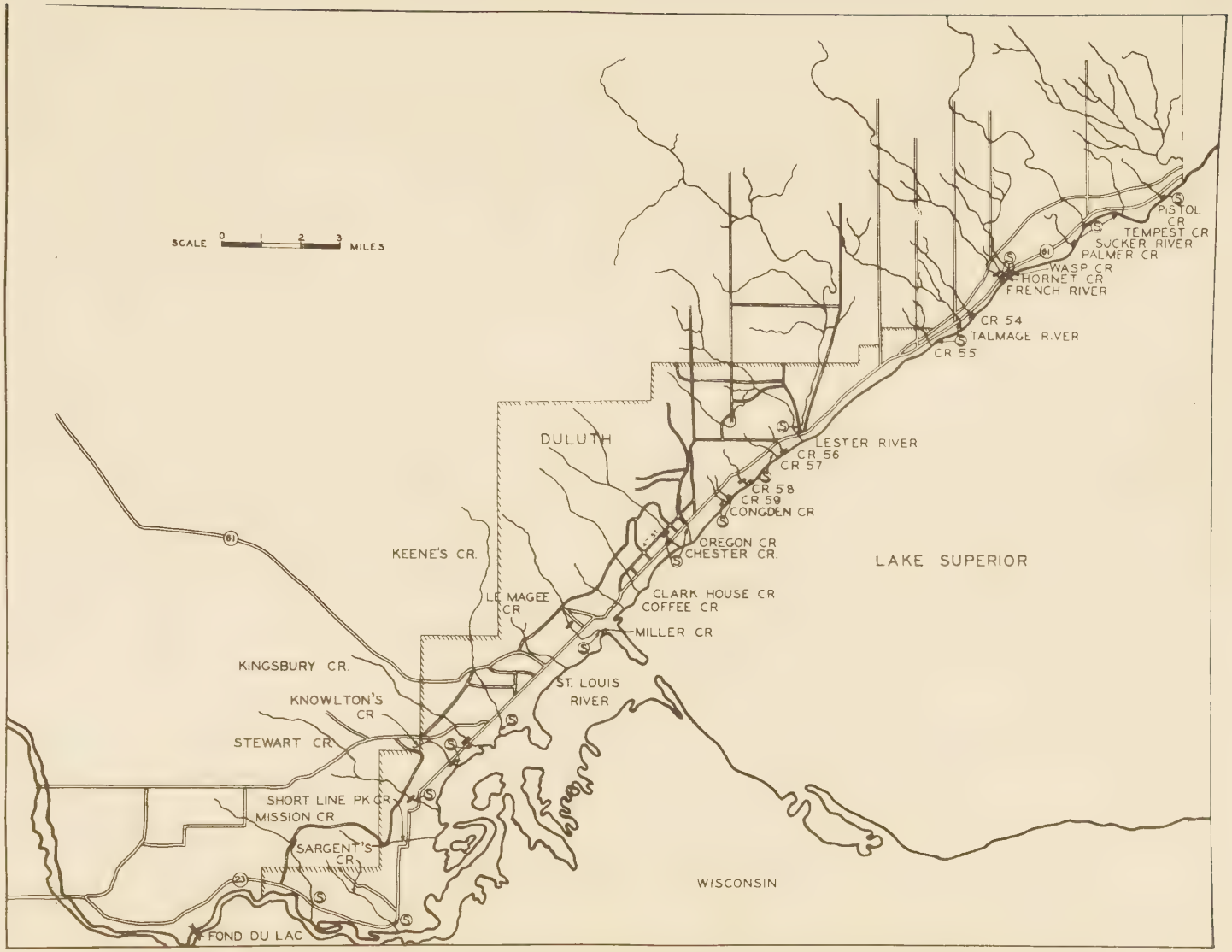


FIGURE 6. SHORELINE OF ST LOUIS COUNTY, MINNESOTA

Table 5.--Productive potential, recommended control devices, and miscellaneous factors concerning streams in St. Louis County, Minnesota
(Survey made in 1952)

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Pistol Cr. 52N-12W-1	1	5	0.1	58 (7-29)	Small	Small size, irregular bottom, scouring, water level fluctuations, drying, lack of larval habitat	---	2' concrete lip in culvert
Tempest Cr. 51N-12W-2	3	10	0.5	61 (7-29)	Small	Same as above	---	1' x 15' concrete barrier in culvert
Sucker R.[2] 51N-12W-3	33	50	1.5	58 (7-30)	Medium	Partial barrier	---	75' electrical device 200' above mouth; power lines 0.25 mile above mouth
Palmer's Cr. 51N-12W-10	2	7	0.5	57 (7-30)	Small	Poor spawning medium, small size, water level fluctuations, scouring	---	10' concrete barrier in culvert
Wasp Cr. 51N-12W-17	6	30	0.3	62 (7-30)	Medium	Small size, drying, partial barrier	---	20' concrete barrier in culvert; possible spawning below culvert
Hornet Cr. 51N-12W-17	2	6	0.3	60 (7-30)	Small	Small size, scouring, water level fluctuations, drying, poor spawning medium	---	20' electrical device 50' below bridge

Table 5, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
French R. 51N-12W-17	18	15	0.7	61 (7-29)	Medium	Scouring, irregular bottom	0.1 mi.	20' electrical device; power lines at site
Talmage R. 51N-12W-19	6	10	0.5	64 (7-29)	Medium	Scouring, irregular bottom	---	30' electrical device; 150' above mouth; possible spawning below
Creek No. 55 51N-13W-25	3	3	0.2	61 (7-29)	Medium	Small size, scouring, water level fluctuations	---	12' electrical device 70' above mouth; power lines at site
Lester R.[2] 50N-13W-8	43	15	0.7	59 (7-30)	Large	Irregular bottom, scouring	---	130' electrical device 100' above mouth; lake effect problem
Creek No. 57 50N-13W-8	1+	2	0.2	59 (7-30)	Medium	Irregular bottom, scouring, partial barrier occasionally at mouth	---	18' electrical device 70' above mouth; power lines at highway
Creek No. 58 50N-13W-18	5	2	0.2	59 (7-30)	Small	Small size, irregular bottom, scouring, drying	0.25 mi.	10' concrete barrier 40' above mouth
Creek No. 59 50N-14W-13	1+	1	0.2	59 (7-30)	Medium	Small size, irregular bottom, scouring, partial barrier occasionally at mouth	---	11' electrical device 100' above mouth; power lines 225'

Table 5, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Congdon Cr. 50N-14W-13	1+	5	0.4	60 (7-30)	Medium	Irregular bottom	---	40' electrical device 200' above mouth; power lines 300' at highway
Oregon Cr. 50N-14W-23	1+	6	0.5	57 (8-4)	Small	Small size, drying, scouring, steep gradient	---	Mouth not found; lower portion of stream underground
Chester Cr. 50N-14W-23	6	12	0.7	57 (8-4)	Small	Steep gradient, scouring, no larval habitat, water level fluctuations	0.25 mi.	3' x 8' concrete barrier just above mouth; lower stream partly underground
Millers Cr. 50N-14W-33	10	5	---	71 (8-1)	Medium	Irregular bottom, oil pollution	0.5 mi.	18' electrical device 300' above mouth; power lines just below at railroad
Keene's Cr. 49N-14W-19	9	5	0.3	68 (8-1)	Medium	Irregular bottom, drying	---	10' electrical device 400 yards above mouth; power lines 750'
Kingsbury Cr. 49N-15W-13	3	6	0.4	69 (8-1)	Small	Irregular bottom	0.2 mi.	10' concrete barrier in railroad culvert
Knowlton's Cr. 49N-15W-23	5	4	0.2	62 (8-1)	Medium	Water level fluctuations	0.25 mi.	25' electrical device at railway bridge 750' above mouth

Table 5, continued

Name of stream[1] and mouth location	Total length in mi.	Aver. width feet[3]	Aver. depth feet[3]	Temp. F (date)	Productive potential	Possible limiting factors	Distance of barrier above mouth	Remarks (Control structures recommended)
Stewart Cr. 49N-15W-23	3	10	0.5	55 (8-4)	Small	Irregular bottom, drying, water level fluctuations	0.25 mi.	10' electrical device at mouth; power lines 200'
Sargent's Cr.[2] 48N-15W-10	5	15	1.0	63 (7-31)	Medium	Possible pollution in St. Louis River	---	15' electrical device 150' above mouth; dikes necessary
Mission Cr.[2] 48N-15W-5	5	20	0.9	63 (7-31)	Medium	Possible pollution in St. Louis River	---	Electrical device at mouth

1/ List includes only those streams which appear to have a productive potential.

2/ Stream is one of a group of 22 in Minnesota which appear to be more suited to sea lamprey spawning than the other streams with a productive potential. These streams should be closely checked for spawning in the future since they will probably be the first to be utilized.

3/ Applicable only to the surveyed portion of the stream.

The geology, surface features, and stream characteristics of St. Louis County are, in general, similar to those described for Cook County.

Control operations will be aided by the relative accessibility of all streams. Installation and operation of devices will be impeded by rapid fluctuations of water levels. Those streams situated in the center of Duluth will present difficulties unique to them alone.

Several of the St. Louis County streams are probably intermittent.

The survey included all streams from the Lake County border, south to Mission Creek which enters the St. Louis River just below the Fond du Lac Dam, which is a positive barrier in the St. Louis River itself.

Discussion

Lampreys have been reported from the St. Louis, Sucker, and Knife Rivers in Minnesota in recent years. Although actual spawning records are absent from both Minnesota and Wisconsin, the persistent and general increase in scarring of lake trout and other fish along both shorelines is an indication of actual utilization of the local streams for spawning purposes.

Lampreys are occasionally taken by commercial fishermen of both States, although reports are scanty. As many as 10 percent of the fish in certain catches have been scarred. It is likely that the sea lampreys which cause the scarring would attempt to use the local streams for spawning (unless the scarred fish migrated from the eastern portions of the lake where large lamprey populations are known to exist).

Many streams in Wisconsin appear to be suitable for sea lamprey spawning, even as judged from the inadequate examination of 1952. Minnesota streams appear to be generally less suitable, as determined from a much more thorough examination. Nevertheless, at least 22 of the 156 streams examined along the north shore of Minnesota are considered to be quite suitable for spawning, despite the fact that some of them contain barriers a short distance above the mouths or are subject to rapid fluctuations in water levels.

All of the suitable streams in both Wisconsin and Minnesota and also those considered to be marginal should be rechecked in the future to determine the actual extent of utilization by sea lampreys. (Rechecks of certain Michigan streams surveyed in 1950 have revealed a slight increase in the numbers of nests present).

It is suspected from our observations to date, that the streams of Wisconsin and Minnesota (although less suitable than those in Michigan) can support spawning runs of considerable size. The 1952 survey of the streams of Wisconsin was inadequate insofar as it told us little about the productive potentials of the streams, and nothing about the actual extent of utilization of the streams; little control work of any nature is possible in this area until a great deal more information is gained.

The inadequacies of the survey of the streams of the Minnesota area were the result of the extreme rapidity of the survey, and the probability that sea lampreys are not utilizing the streams to the extent which they may in the future. In any event, no lampreys or nests were found. The actual evaluation of the importance of the streams is based on single examinations. Generally speaking, it is doubtful if many of the streams considered to have a large productive potential (room for 75 or more nests) can provide room for nests in the quantities (several hundred nests or more) already observed in some of the streams of eastern Lake Superior or Lakes Huron and Michigan. Even in the 22 streams considered to be the most favorable of the 156 examined, areas for hundreds of nests are probably not available. However, construction of as many as 75 nests in any single stream will (if spawning and survival are successful) demand serious control operations.

A number of the 22 favorable streams contain spawning habitat for less than 75 nests, and have a medium productive potential; it is likely that lampreys will spawn more successfully in these streams than many others with a large productive potential (productive potential is based upon the number of nest sites available and not the final production of the stream in adult lampreys, since the latter is more or less an unknown quantity; i.e. a stream with an area suitable for 25 nests and possessing favorable temperatures will be suitable for lampreys, whereas a stream with room for 125 nests with temperatures hovering around the minimum spawning temperature of 53 to 56 is likely to be unfavorable much of the time at least).

I have been asked to list the 22 most favorable Minnesota streams in the order of their importance, and from an efficient initial control operations standpoint (i.e. in which streams should the first control structures be constructed?). The listing is, of course, an educated guess; the order has been influenced by the relative productive potentials, the general favorability, the size of the streams, and the probable relative difficulties which will hinder construction, maintenance, and operation of control structures. (Lampreys have been observed in the Sucker and Knife Rivers in recent years but their presence has not been used as a criterion for intitial control, since lampreys are also probably present in some of the other streams.) The suggested order of construction is as follows:

Most favorable streams: (Tables 3 and 4)

1. Split Rock River: Large productive potential, 75' electrical device.

2. Reservation River: Large productive potential, 30' electrical device.

3. Indian Camp Creek: Medium productive potential, 20' electrical device.

4. Palisade Creek: Medium productive potential, 30' electrical device.

5. Gooseberry River: Large productive potential, control difficult due to large size of river and reversing current.

6. Arrowhead River: Medium productive potential, control difficult due to large size of mouth area and shifting sand bars.

7. Pigeon River: Medium productive potential, control difficult due to large size of river, reversing current, and pulp wood operations.

Slightly less favorable streams: (Tables 3 and 4)

8. Flute Reed River: Large productive potential, 25' electrical device.

9. Stewart River: Large productive potential, 75' electrical device.

10. Baptism River: Large productive potential, 100' electrical device.

11. Devil's Track River: Large productive potential, 110' electrical device.

12. Knife River: Large productive potential, 130' electrical device.

13. Lester River: Large productive potential, 130' electrical device, control difficult due to lake effect.

14.	Sucker River:	Medium productive potential, 75' electrical device.
15.	Cross River:	Medium productive potential, 65' electrical device.
16.	Two Island River:	Medium productive potential, 45' electrical device.
17.	Dragon Creek:	Medium productive potential, 20' electrical device.
18.	Creek No. 2:	Medium productive potential, 25' electrical device.
19.	Sargent's Creek:	Medium productive potential, 25' electrical device.
20.	Mission Creek:	Medium productive potential, 25' electrical device.
21.	Silver Creek:	Medium productive potential, 70' electrical device, control difficult due to reversing current.
22.	Beaver River:	Medium productive potential, 60' electrical device, control difficult due to reversing current.

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